Benchmarking the Productivity Performance of New Zealand's Frontier Firms

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Abstract

This study compares the relative performance of New Zealand's firms to several small advanced economies using novel cross-country microdata from CompNet. We present stylised facts for New Zealand relative to Belgium, Denmark, Finland, Netherlands and Sweden based on average productivity levels, as well as benchmarking laggard, median and frontier firms. This research also employs an analytical framework of technology diffusion to evaluate the extent of productivity convergence, and the impact of the productivity frontier on non-frontier firm performance. Results show that New Zealand's firms have comparatively low productivity levels and that its frontier firms are not benefiting from the diffusion of best technologies outside the nation. Furthermore, there is evidence of labour misallocation in New Zealand based on less labour-productive firms having disproportionally larger employment shares than their more productive counterparts.

Productivity measures how efficiently production inputs (e.g. capital, labour and raw materials) are used to produce goods and services. Productivity is a key driver of sustainable income growth and an important source of cross-country differences in per capita income.

New Zealand's productivity performance has been poor over the last two decades. This position has often been labelled a 'pro-

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ductivity puzzle', because the country follows good practice in many policy fundamentals. For example, New Zealand ranks high internationally on measures such as ease of starting a business and ease of doing business, lack of corruption, and flexible labour market regulations.[2] Yet, the quality of these settings has not been sufficient to propel productivity growth, and as such improvements in labour productivity make a minimal contribution to New Zealand's economic growth. Yet, the quality of these settings has not been sufficient to propel productivity growth.

The New Zealand Productivity Commission is undertaking an inquiry into New Zealand's frontier firms. The Government asked the Commission to investigate how the economic contribution of frontier firms can be maximized through policies aimed at 1) improving the performance of frontier firms themselves; and 2) helping innovations diffuse more effectively from frontier firms to non-frontier New Zealand firms.

Given the research objectives of the Commission inquiry, the Competitiveness Research Network (CompNet) dataset is an ideal data source for assessing the performance of New Zealand firms relative to comparable countries. These data include a rich set of micro-aggregated productivity indicators at both the national and macro-sector level and allows longitudinal investigation as annual data are available from 2003 to 2016. Analysis in this study is also broken down into two time periods: pre-Global Financial Crises (GFC) (2003-08) and post-GFC (2009-16). The comparable countries used are the small advanced economies (SAEs) with information available in the CompNet database. These include Belgium, Denmark, Finland, Netherlands, and Sweden. Other SAEs would also be useful comparators, such as Singapore, Ireland and Israel. However, these data are not available in the CompNet database.

This research has three main research objectives:

- present stylized facts regarding average productivity levels and growth rates for New Zealand, in comparison to SAEs (both at the national and macro-sector levels). This includes benchmarking laggard, median and frontier firms;
- provide an analytical framework for evaluating diffusion and the extent of productivity convergence for New Zealand relative to SAEs; and
- review the allocation of resources (capital and labour) across the productivity distribution in New Zealand and SAEs.

As is evident in all three objectives, the focus of the empirical analysis in this article is the comparison of New Zealand with SAEs. This provides a comparative understanding of three broad drivers of aggregate productivity growth: innovation (which translates into productivity growth of the frontier firms and movement towards the international frontier); diffusion

2 For example, New Zealand ranked 1st in both the World Bank Ease of Doing Business Index 2019; equal 1st in the Transparency International Corruption Perceptions Index 2019; and 7th and 10th respectively for the OECD indicators for product market regulation and employment protection legislation. The two OECD indicators aim to proxy ease of starting a business; and flexibility of labour market regulations, respectively (New Zealand Productivity Commission, 2021).

(the spread of technology, knowledge and practices between the frontier firms and non-frontier firms); and reallocation (the movement of resources across firms). The evidence will provide greater understanding of the extent to which New Zealand's relatively poor productivity performance is due to weak innovation (based on distance to the comparable SAE frontier); slow adoption of new technologies by New Zealand frontier firms and diffusion of innovation to non-frontier firms; and/or the mis-allocation of resources.

This study is one of a number of research inputs into the Commission's frontier firms inquiry.[3] The article is organized as follows: Section 1 outlines the data and key definitions; Section 2 compares the productivity patterns between New Zealand and other SAEs; Section 3 presents descriptive and econometric evidence on productivity convergence for both New Zealand and other SAEs; Section 4 focusses on resource allocation; Section 5 presents simulations to hypothesize the counterfactual scenario for New Zealand if there were gains in productivity convergence as well as resource allocation; and Section 6 provides a brief conclusion with directions for future research.

Data

Data come from CompNet, a unique micro-aggregated annual database covering 19 countries. To ensure harmonized cross-country data, CompNet implements distributed micro-data analysis developed by Bartelsman *et al* (2004). In this approach, a common Stata programme is used to extract relevant information, aggregated in such a way to preserve confidentiality from existing firm-level datasets available within each National Central Bank or National Statistical Institute. This methodology harmonises industry coverage, variable definitions, estimation methodologies and sampling procedures, as far as the underlying raw data permits.[4]

The analysis conducted in this article is based on the 7th vintage CompNet data.[5] At the time of writing, New Zealand's data had not been formally included in the 7th vintage version. Accordingly, we applied the Stata programme provided by CompNet to firm-level information in Statistics New Zealand's Longitudinal Business Database (LBD). We also used information from Stats NZ's Integrated Data Infrastructure (IDI) for deriving the labour productivity variable. While the New Zealand data are sourced separately from the LBD and IDI, it is put in the required CompNet structure and so we forthwith collectively refer to data for New Zealand and comparator economies as CompNet data.[6]

3 For other research inputs, see https://www.productivity.govt.nz/inquiries/frontier-firms/.

4 More information can be found in https://bschool.nus.edu.sg/strategy-policy/productivity-research-network/.

5 More detailed information can be found in the following webpage https://www.comp-net.org/data/7th-vintage/.

6 Stats NZ Disclaimer: These results are not official statistics. They have been created for research purposes from the Integrated Data Infrastructure (IDI) and the Longitudinal Business Database (LBD) which are carefully managed by Stats NZ. For more information about the IDI and/or LBD, please visit https://www.stats.govt.nz/integreated-data/.

CompNet data contains micro-aggregated indicators at the national and macro-sector levels.[7] These indicators cover six broad categories including competitiveness, finance, labour, productivity, trade and firm dynamics. For this study, a subset of indicators from the productivity and labour categories at the national and macro-sector levels are used. Macro-sectors are similar to one-digit industries under the Australia-New Zealand Standard Industry Classification 2006 (ANZSIC 2006)[8] and this study uses the term 'macro-sector' and industry interchangeably. One limitation of these data is that the sample excludes the financial, agricultural and mining sectors.

The CompNet dataset has two samples: the "all" sample and the "20e" sample. The "all" sample includes firms with one or more employees in the target population, while the "20e" sample includes only firms with 20 or more employees. For the purposes of this research, the "all" sample is the preferred dataset as small firms between 1 and 19 employees play an important part in the New Zealand economy. These firms account for 78 per cent of the entire firm population (excluding working proprietors) and 31 per cent of total employment.[9]

For this research, SAEs are our main focus. These include Belgium, Denmark, Finland, Netherlands and Sweden, as well as New Zealand. These economies are IMF advanced economies with a population ranging from 1 to 20 million people and with a per capita income above US $30 000. Skilling (2020:6) suggests "small advanced economies are a very useful comparator group for New Zealand in understanding the priorities for action in strengthening productivity performance".

Data source and profile

Table 1 provides the sample size on an annual basis for each comparator SAE and New Zealand. Note that for the majority of economies data exist for the period 2003 to 2016.[10] The exceptions are the Netherlands, whose the sample begins in 2007; and Denmark, whose sample is restricted to

7 The Competitiveness Research Network (CompNet) is a research network originally founded by the European System of Central Banks in 2012 to foster the debate on competitiveness issues among policy institutions and researchers. It produces micro-founded datasets covering productivity indicators for a growing number of countries. Since 2017, CompNet is an independently funded and regulated network, hosted at the Halle Institute for Economic Research (IWH). The dataset, now at its 7th vintage, is available to researchers on request. More information available at https://www.comp-net.org/about-us/the-network/

8 Macro-sectors have been broadly matched to the appropriate ANZSIC category, based on descriptions in both classification manuals.

9 These figures are based on the Business Demography Statistics 2019 from Statistics New Zealand.

10 Note that this sample approximately covers 80 per cent of total employment across the nine macro-sectors in each of the SAEs. The data for Denmark actually begins in 2000, but due to a structural break in the labour productivity variable between 2003 and 2004, we focus on data from 2004 onwards.

11 It is also worth noting that the Belgian data is of a higher-level aggregation relative to other countries with firm-level data in our sample. It is based on data from Bank of the Accounts of Companies Harmonised (BACH) and European Committee of Central Balance Sheet Data Offices (ECCBSO), which build aggregated financial statements from firm-level data. These data are then reconstructed into the structure designed by CompNet. As such, the small sample size counts for Belgium in Table 1 are not firm counts, but numbers of aggregate cells.

Table 1: Sample Size of the CompNet Database (Number of Firms)

Year	Belgium	Denmark	Finland	Netherlands	New Zealand	Sweden
2003	23 728		97 702		49 452	111 140
2004	24 203	142 553	97 970		51 942	109 827
2005	23 588	140 482	96 189		54 438	111 022
2006	23 087	144 926	99 362		56 484	109 841
2007	23 189	145 709	101 157	83 292	57 801	108 875
2008	22 189	148 974	104 821	88 808	59 412	101 740
2009	21 543	142 087	103 721	89 919	58 833	98 819
2010	21 152	141 963	104 270	90 562	57 189	105 483
2011	23 714	145 689	101 465	94 061	57 387	108 783
2012	24 142	146 979	105 636	93 581	57 552	108 595
2013	20 421	146 004	100 704	93 096	59 208	109 166
2014	19 526	144 747	98 758	93 353	61 320	111 503
2015	18 576	142 146	98 093	93 989	62 391	111 007
2016	17 054	146 909	97 838	95 538	61 209	111 724

Note: The sample size indicates the number of annual average firm-level observations (except for Belgium) used in the calculation of value-added labour productivity. Sample size may slightly vary for other variables due to different variable definitions and treatment of outliers.
Source: Authors' calculations using CompNet.

Table 2: Firm Shares by Macro-Sector (% of all Firms in CompNet Database)

	Belgium	Denmark	Finland	Netherlands	New Zealand	Sweden
Manufacturing	8.7	8.0	11.2	12.4	12.9	10.9
Construction	15.0	15.6	19.1	11.7	21.0	14.1
Wholesale & retail trade	30.0	22.6	21.9	32.3	16.0	25.8
Transport & storage	4.1	5.7	10.4	5.0	5.6	5.4
Accommodation & food	9.5	6.6	5.5	4.9	13.4	5.7
Information & communication	4.7	6.2	4.0	7.0	1.4	5.6
Real estate & rental services	5.7	12.6	6.5	-	7.2	6.0
Scientific & technical services	16.4	15.0	15.3	19.5	16.2	21.2
Admin & support services	5.8	7.6	6.1	7.3	6.2	5.2

Notes:
1. Firm shares are average over the period 2003-16.
2. The real estate and rental services sector is not available in the Netherlands.
Source: Authors' calculations using CompNet.

starting in 2004. Sources of data for country are provided in Appendix A. [11]

Table 2 provides contextual background regarding industry composition across the countries that are part of this empirical analysis.[12] It provides firm shares by macro-sector. Relative to the SAEs, New Zealand appears to have greater concentration of firms in manufacturing (12.9 per cent), construction (21.0 per cent) and accommodation and food service sectors (13.4 per cent). At the other end of the firm share scale, New Zealand has a smaller proportion of firms in wholesale and retail trade (16.0 per cent) and information and communication (1.4 per cent), again relative to other SAEs.

Definitions

Table 3 defines the key variables of interest. A key firm performance measure is labour productivity. It is the ratio of real value-added over labour and captures the amount of output produced per worker in a firm. One downside of using labour productivity as a performance mea-

12 According to OECD national accounts, the selected nine macro-sectors account for roughly 65 per cent of total GDP across the SAEs.

Table 3: Key Variables Definitions

Variable	Definition
Value added	Gross annual revenue minus cost of intermediate materials.
Labour	Headcounts of the number of employees (yearly average) with employed shareholders/owners excluded.
Labour productivity	Value-added per unit labour input.
Unit labour cost	Ratio of labour cost over value-added.
Price-cost margin	The ratio of value-added to labour and capital costs.
Foreign ownership	Share of firms that have more than 50% of their shares controlled by foreign owners.
Young firms	Share of firms that have been established in the last 5 years.
Exit firms	Share of firms that exit the market in subsequent year.

Note: Value-based variables (value-added, labour productivity and unit labour cost) are expressed as real euros at the 2005 price by taking country-industry specific deflators and country-level PPP from the Eurostat-OECD PPP programme.
Source: CompNet user guide.

sure is that it does not capture the impact of other inputs, such as capital and intermediate materials. The common alternative performance measure is multifactor productivity (MFP), which quantifies labour, capital and materials in production functions. However, when making cross-country comparisons of MFP, strict assumptions are required regarding identical technologies across countries, which means that MFP may suffer more measurement bias than labour productivity. Consequently, this study employs labour productivity as the key metric of interest, particularly given its common use in the literature and the ease with which it allows cross-country comparisons.[13]

Within our data sample, firms in a given industry within the same country are divided into mutually exclusive productivity deciles in each time period of interest. This division allocates an equal number of firms in each decile based on their labour productivity levels. Decile 1 (10) represents the least (most) productive firms situated at the bottom (top) 10 per cent of the productivity distribution at a point in time.

In this study, we adopt the following definitions to classify firms into three classes in each industry.

- **Laggard firms** - firms situated at or below the 10th percentile (decile 1) of the labour productivity distribution in the industry within a country.
- **Median firms** - firms situated between the 40th and 60th percentile (deciles 4 and 5) of the labour productivity distribution in the industry within a country.
- **Frontier firms** - firms situated at or above the 90th percentile (decile 10) of the labour productivity distribution in the industry within a country.[14]

In the upcoming empirical analysis, we also focus on frontiers at the national level. This is derived for each of the six SAEs.

- **National frontier** – the weighted

13 All subsequent descriptive and econometric analysis in Sections 2 and 3 were also conducted using MFP as the outcome of interest (for robustness purposes), and results were qualitatively similar.

14 This definition is broadly similar to the existing literature (Bartelsman *et al.*, 2008; Griffith *et al.*, 2009). Other studies use the top 5 per cent or top 50 or 100 of firms with the highest productivity distribution (Andrews *et al.*, 2015; OECD, 2015). Their empirical results generally show similar productivity patterns and movements and do not appear to be sensitive to the choice of frontier firm definition.

Table 4: Industry SAE Frontiers by Macro-Sector

	First	Second	Third
Manufacturing	Belgium	Sweden	Netherlands
Construction	Netherlands	Finland	Sweden
Wholesale & Retail	Denmark	Sweden	Belgium
Transportation & Storage	Belgium	Sweden	Netherlands
Accommodation & Food	Sweden	Finland	Netherlands
Information Communication	Belgium	Sweden	Netherlands
Real Estate & Rental Services	Sweden	Belgium	Finland
Professional Services	Belgium	Netherlands	Sweden
Administrative Services	Belgium	Sweden	Netherlands

Note: First, second, third indicate ranks of industry productivity frontier in each industry.
Source: Authors' calculations using CompNet.

average of a country's nine industry frontiers. Weights are based on the number of firms in each industry from the business register in the country.

Finally, in the productivity convergence analysis in Section 3 of this study, we also construct an SAE frontier to then derive the productivity gap with each country's national frontier. To construct the SAE frontier, we start by first defining an Industry SAE frontier, which is the average of the industry frontiers of the three countries that have the highest average labour productivity over the whole data period.

Note that the definition of the industry SAE frontier takes long-run averages of the industry productivity frontier over 2003-16 across six economies and uses those with the highest three averages. The main advantage of this definition is to fix a constant set of industry productivity frontiers over time. Once an industry productivity frontier is selected, it remains as the industry SAE frontier for the entire sample period.

Table 4 presents the list of countries that define the Industry SAE frontier across the nine macro-sectors. For example, in the manufacturing sector, the top three productivity frontiers are Belgium, Sweden and Netherlands. Collectively, they form the manufacturing SAE frontier.

We then use the industry SAE frontiers to derive the SAE frontier as follows:

- **SAE frontier** - the weighted average of the Industry SAE frontiers from Table 4. Weights are based on the number of firms in a country-industry at the Industry SAE frontier from business registers.

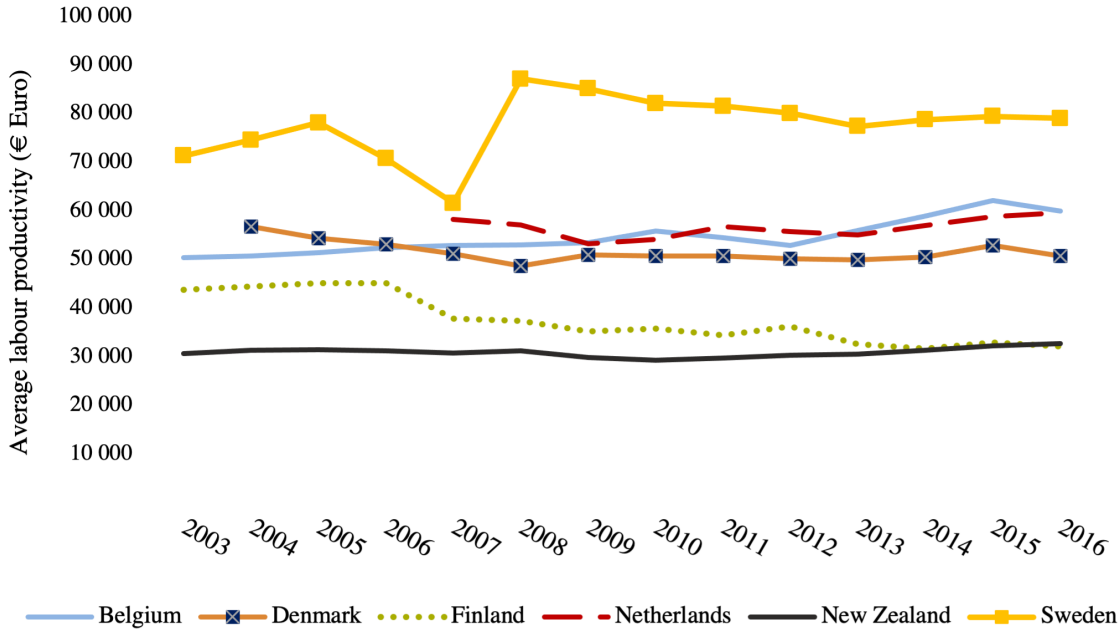
Productivity patterns

To generate insights on the performance of New Zealand firms across the productivity distribution relative to its SAE counterparts, this section presents stylized facts on average productivity, as well as benchmarking laggards, median and frontier firms.

Average productivity

Average labour productivity across the SAEs for the period 2003 to 2016 is shown in Chart 1. The estimates are converted into a standard currency (euros) and deflated to constant 2005 prices. Sweden is the highest performing country with respect to this metric and produces 77,700 euros per employee on average, over the period 2003 to 2016. This was followed by the Netherlands (€56,700), Belgium (€54,700), Denmark (€51,700) and Finland (€37,600). New Zealand had the lowest average labour productivity, generating 31,000 euros per

Chart 1: Average Labour Productivity Levels across SAEs.



Notes:
1. Each line shows the average labour productivity of a country over the 2003-16 period. Average labour productivity is the weighted average of labour productivity at the macro-sector level.
2. Denmark and Netherlands data start from 2004 and 2007 respectively.
3. Estimates are converted into a standard currency (Euros) and deflated by taking country-industry specific deflators and country-level PPPs from the Eurostat-OECD programme (2005 prices).
4. The dip of the Swedish average labour productivity in 2007 is likely attributable to inadequate adjustments for a large reclassification of sectors.For the sake of robustness, we test whether the empirical findings in Section 4 change if we exclude pre-2008 Swedish data and find the general findings are qualitatively similar.

Source: Authors' calculations using CompNet.

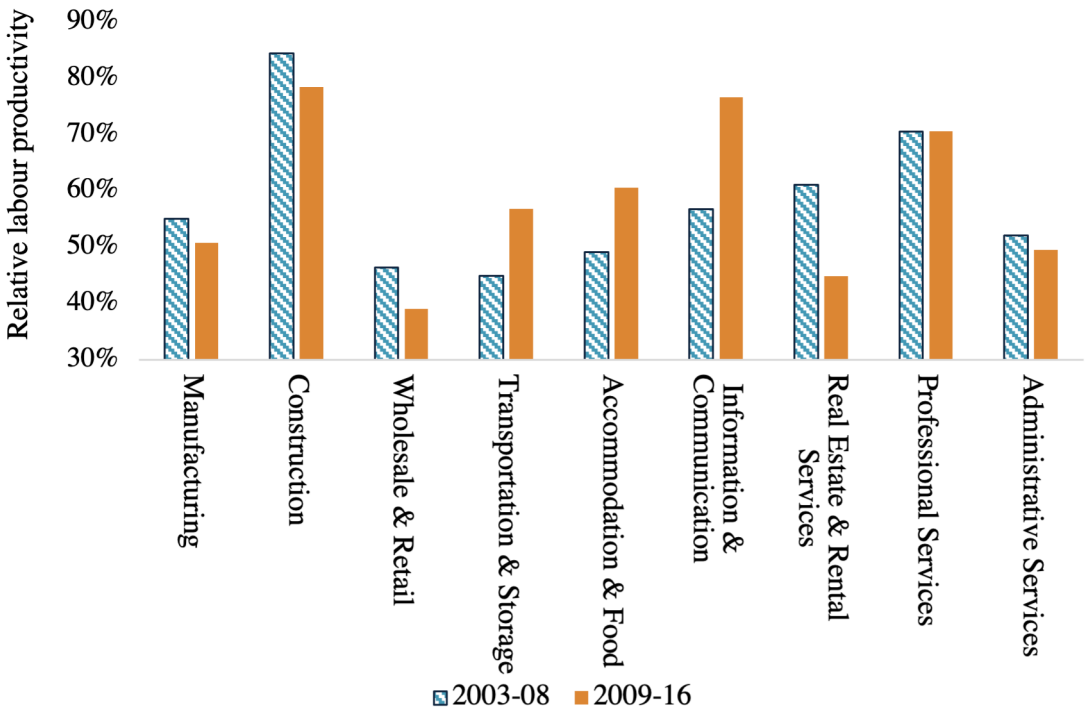
employee.

New Zealand's average labour productivity levels over the sample period equate to a relative productivity of approximately 53 per cent of the SAE average. This is a stark finding as the interpretation is that an average New Zealand firm produces just over half of the total amount of output produced by the other countries using the same amount of labour input. Despite being substantially behind the labour productivity levels in other SAEs, New Zealand exhibits little sign of catching up. The labour productivity growth rate is broadly similar to the average comparable rate for the other SAEs (0.51 per cent per annum compared to 0.49 per cent per annum for the other SAEs).

The next set of descriptives breaks down the national labour productivity levels into macro-sectors (Chart 2 and Table 5). Comparing relative productivity levels pre and post-GFC (ie, 2003-08 vs 2009-16), we find that six out of nine macro-sectors in New Zealand were less productive over time relative to the average of their SAE counterparts. This includes manufacturing, construction, wholesale and retail trade, real estate and rental services and administrative and support services. Among these industries, the wholesale and retail trade sector had the lowest relative productivity ratio post-GFC of just below 40 per cent over the period 2009-16.

As Chart 2 shows in three out of nine macro-sectors, there was a marked improvement in New Zealand's relative productivity between 2003-08 and 2009-16.

Chart 2: Labour Productivity by Macro-Sector in New Zealand, Relative to Small Advanced Economies



Note: Relative labour productivity is the ratio of average labour productivity level in New Zealand over average labour productivity in the other five SAEs.
Source: Authors' calculations using CompNet.

Table 5 provides context for these trends. It shows that for two of these sectors (transport storage; accommodation and food), the improvement in relative productivity was primarily driven by a negative labour productivity growth rate across other SAEs. Only in the sector of information communication did relative productivity improve due to a substantially higher positive labour productivity growth rate in NZ compared to the average across other SAEs.

Benchmarking laggard, median and frontier firms

Expanding the above analysis on averages, this section takes a closer looks at the distribution of firm performance (with respect to labour productivity) for New Zealand relative to the other five SAEs. Chart 3 presents relative productivity levels and reveals three insights:

- New Zealand's laggard firms show gradual improvements in labour productivity from 51.8 per cent in 2003 to 65 per cent in 2016, relative to laggards in other SAEs. This upward trend is mainly driven by large pro-

15 The catch-up of laggard firms in New Zealand could reflect, amongst other things, within-firm improvements in productivity of surviving firms, and/or an increasing connection between firm exit and productivity. Future research could delve further into modelling and thus decomposing the alternative channels of catch-up.

Table 5: Labour Productivity Growth by Macro-Sector in New Zealand and Five Small Advanced Economies, 2003-16 (Average Annual Rate of Change)

	New Zealand	SAEs
Manufacturing	0.5	1.2
Construction	-0.2	0.1
Wholesale & Retail	1.4	3.6
Transportation & Storage	0.7	-2.3
Accommodation & Food	0.2	-2.5
Information & Communication	4.4	0.6
Real Estate & Rental Services	0.8	2.8
Professional Services	0.1	0.0
Administrative Services	0.3	0.3

Source: Authors' calculations using CompNet.

ductivity declines in SAEs: -1.1 per cent per annum on average compared to 0.6 per cent per annum in New Zealand.[15]

- The performance of New Zealand's median firms remains stable relative to the corresponding labour productivity levels across the SAEs – averaging at 54.6 per cent.
- The productivity of New Zealand's national frontier steadily declined relative to that of frontier firms in SAEs, from 51.5 per cent in 2003 to 43.5 per cent in 2016. This relative drop reflected slower average productivity growth among New Zealand frontier firms, 0.4 per cent per annum vs 1.7 per cent per annum in SAEs.

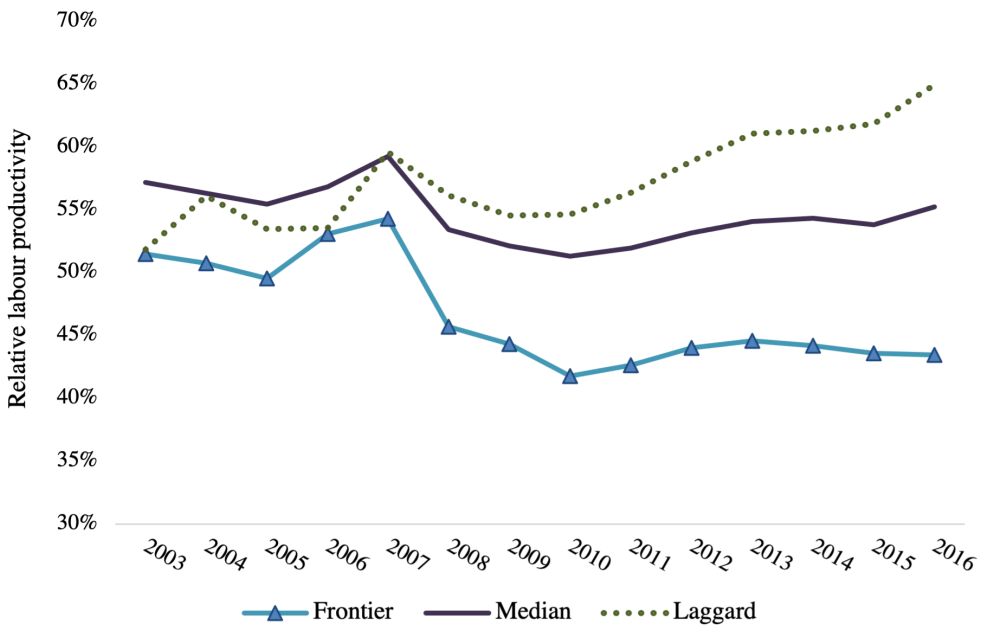
These insights highlight both positive and negative news - the converging trend for New Zealand laggards and the diverging trend for New Zealand frontier firms, relative to their SAE counterparts at the bottom and top of the labour productivity distribution, respectively.

To breakdown the insights from Chart 3 by macro-sector, Table 6 illustrates the change in relative labour productivity between the time periods of 2003-08 and 2009-16 for each sector. The productivity divergence for New Zealand's frontier firms is observed in six out of nine macro-sectors. For five of these six, the decline was greater than 5 percentage points, as indicated by the double downward arrow in Table 6. A single downward arrow reflects a decline in relative labour productivity of less than 5 percentage points.

There are three sectors where frontier firms in New Zealand performed better than their SAE counterparts – the same three that were also the best performers when looking at all firms. Furthermore, the same pattern emerges that for two of these sectors (transport and warehousing; and accommodation and food) this is attributable mainly to a decline in average labour productivity in SAE frontier firms; while for just one sector (information communication), this is driven by large positive labour productivity growth of New Zealand frontier firms.[16] Overall, these results clearly show that most of New Zealand's best performing firms have struggled to keep pace with frontier firms in other SAEs.

16 Over the period 2003 to 2016, the average labour productivity growth rate for NZ frontier firms in information and communication was 4.35 per cent, while the corresponding estimate for SAEs was 1.12 per cent.

Chart 3: Labour Productivity, by Laggard, Median and Frontier Firms in New Zealand Relative to Small Advanced Economies, 2003-2016



Note: Each line is the ratio of the labour productivity level in New Zealand to average labour productivity across the other SAEs in a specific class of firms (laggard, median and frontier).
Source: Authors' calculations using CompNet.

Table 6: Change in Relative Labour Productivity in New Zealand Between 2003-08 and 2009-16, by Macro-Sector

	Frontier	Median	Laggard
Manufacturing	↓↓	↓	↑
Construction	↓↓	↓↓	↑
Wholesale & Retail	↓↓	↓↓	↑
Transportation & Storage	↑	↑	↑
Accommodation & Food	↑	↑	↑
Information Communication	↑	↑	↑
Real Estate & Rental Services	↓↓	↓↓	↓↓
Professional Services	↓	↑	↑
Administrative Services	↓↓	↓	↑↑

Note: ↓↓, ↓, ↑ and ↑↑ indicates respectively that relative productivity dropped by more than 5% points, dropped between 5% and 0% points inclusive, increased between 0% and 5% points inclusive, and increased by more than 5% points.
Source: Authors' calculations.

On the other hand, New Zealand's laggard firms have a converging trend towards their SAE counterparts. There is only one macro-sector where this trend was not evident – real estate and rental services.

Firm characteristics

Table 7 provides descriptive statistics for firm characteristics available in CompNet between New Zealand and other SAEs. Comparisons are made across the three firm types (laggard, median and frontier firms), while our commentary focusses on frontier firms in particular. Several patterns are evident. As expected, value-added increases as we move from laggard to median and then onto frontier firms. It is notable though that the increase in value-added when moving from a median to a frontier firm in New Zealand is ap-

Table 7: Firm Characteristics, Average 2003-16

	New Zealand			SAEs		
Variables	Laggard firms	Median firms	Frontier firms	Laggard firms	Median firms	Frontier firms
Value-added	74 005	326 890	1 037 890	86 487	348 608	3 068 407
Labour	7.31	12.17	8.42	3.85	7.73	12.17
Labour productivity	10 124	26 860	123 265	22 464	45 098	252 129
Unit labour cost	1.64	0.62	0.26	1.41	0.59	0.33
Price-cost margin	0.08	0.29	0.46	0.34	0.35	0.53
Foreign ownership (%)	1.7	2.4	6.1	0.9	1.3	3.1
Young firms (%)	43.0	27.4	25.4	30.3	15.7	15.0
Exit firms (%)	14.3	8.0	5.9	8.7	3.8	2.4

Notes:
1. Figures for SAEs are the firm-population weighted averages of four selected economies (Belgium, Denmark, Finland and Sweden). Netherlands is not included in these descriptives as firm characteristics are not available
2. Definitions of all variables are found in Table 3.
Source: Authors' calculations using CompNet.

proximately a 3-fold increase, whereas the comparable jump in SAEs is close to 9-fold. New Zealand frontier firms are also generally smaller in size than those in the other SAEs, on average employing 8.4 employees compared to 12.2 employees.

In terms of unit labour cost and price-cost margins, frontier firms in New Zealand and SAEs are broadly similar. The unit labour cost is defined as the average cost of labour per unit of output (value-added) produced (as explained in Table 3). It is often viewed as a broad measure of (international) price competitiveness. Price cost margin is a measure of a firm's mark-up and thus captures a firm's ability to increase prices above marginal costs. The similarity in both unit labour cost and price-cost margins across New Zealand and SAE frontier firms suggests that both sets of firms operate in a relatively competitive environment and produce goods and services with more competitive prices compared to laggard and median productivity firms.

With respect to the other firm characteristics available, New Zealand's frontier firms are generally younger, more likely to be foreign-owned and more likely to exit the market in the subsequent year compared to their SAE counterparts. For example, 15 per cent of frontier firms across SAE comparator countries are defined as young, ie, established in the last five years. The corresponding proportion for frontier firms in New Zealand is 25 per cent.

Productivity convergence

The key takeaway from the descriptives in Section 2 is that when comparisons are made to other SAEs, New Zealand's firms are the least productive, with fairly weak productivity growth over the period 2003-16, and no evidence of productivity convergence. The concept of productivity convergence suggests that poor-performing economies (value-added per worker in this case) will tend to grow at a faster rate than better-performing economies due to diminishing returns (particularly, to capital). The lack of productivity convergence in New Zealand, which is consistent with earlier work using national account statistics (Conway, 2017; de Serres *et al.*, 2014; Nolan *et al.*, 2019), indicates persistent productivity gaps with many SAEs

Exhibit 1: A Simplified Framework of Technology Diffusion

Source: Adapted from OECD (2015).

and larger advanced economies.

One of the potential reasons for New Zealand's poor productivity performance, particularly by our frontier firms, is a "breakdown of the diffusion machine" (OECD, 2015:12). In an OECD (2015) report on future of productivity, it was argued that the productivity slowdown in many OECD countries is in part due to the diminished pace of frontier technology diffusion. Global frontier firms have the capability and capacity to innovate, can optimize production processes across global value chains (GVCs), and have the necessary human capital and organization structure to replicate and diffuse new technology and knowledge. Non-frontier firms can improve their performance by adopting frontier technology. The result of poor technology diffusion is a widening productivity gap between non-frontier firms and global frontier firms.[17]

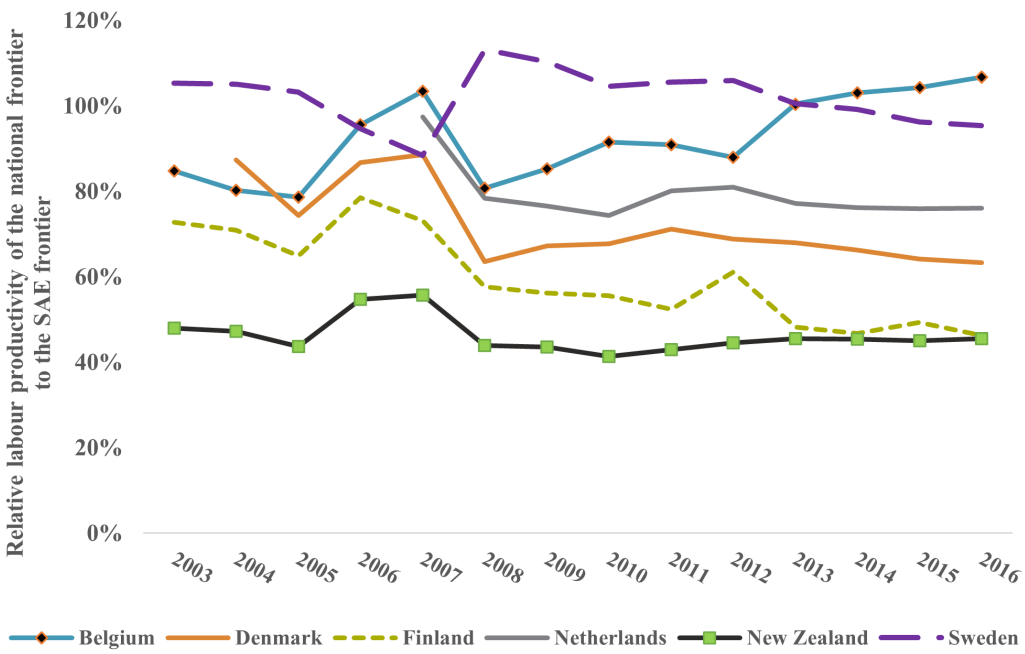
Technology diffusion can be defined as the process of transferring information, knowledge and innovation. The scope for technology diffusion from global frontier firms to non-frontier firms depends on several factors. This includes global connections, foreign direct investment (FDI), participation in global value chains (GVCs), and the mobility of skilled labour (OECD, 2015). For New Zealand, remoteness from foreign markets and weak international connections could therefore be important barriers to achieving productivity acceleration.

This section of the article is focussed on understanding and evaluating the efficiency of technology diffusion in New Zealand.[18] To achieve this aim, we apply an analytical framework from the productivity convergence literature (Andrews *et al.*, 2015; Bartelsman *et al.*, 2008; Griffith *et al.*, 2009). Under this framework (Exhibit 1), and our focus on SAEs in this study, technologies from the SAE frontier are first adopted by the national frontier, the most productive firms in a country. National frontier firms then replicate and adjust these technologies to fit local conditions, which permits greater within-country technology diffusion. If the process of diffusion works well, one may expect to see productivity catch-ups towards both frontiers. In

17 Global frontier firms is the globally most productive firms in advanced economies. Specifically, these frontier firms are the 100 most globally productive firms in terms of multi-factor productivity in each industry (OECD, 2015).

18 Conway *et al* (2015) explored technology diffusion within New Zealand and focussed on multi-factor productivity. That study highlighted that convergence to the frontier is both statistically and economically important. Further, Zheng (2016) explored technology diffusion within New Zealand at both the local region and national level and found that geographic proximity between firms was important in the speed of diffusion.

Chart 4: Relative Labour Productivity of the National Frontier to the Small Advanced Economies (SAEs), 2003-16



Notes: 1.Each line is a ratio of the relevant national frontier to the SAE frontier.
2. Denmark and Netherlands data start from 2004 and 2007 respectively.
Source: Authors' calculations using CompNet.

other words, non-frontier firms converging towards frontier firms within an economy, and the national frontier converging towards the SAE frontier.

To assess the extent of both cross-country and within-country diffusion we begin with descriptives, before using econometric models to quantify the rate of technology diffusion.

Cross-country and within-country productivity gaps

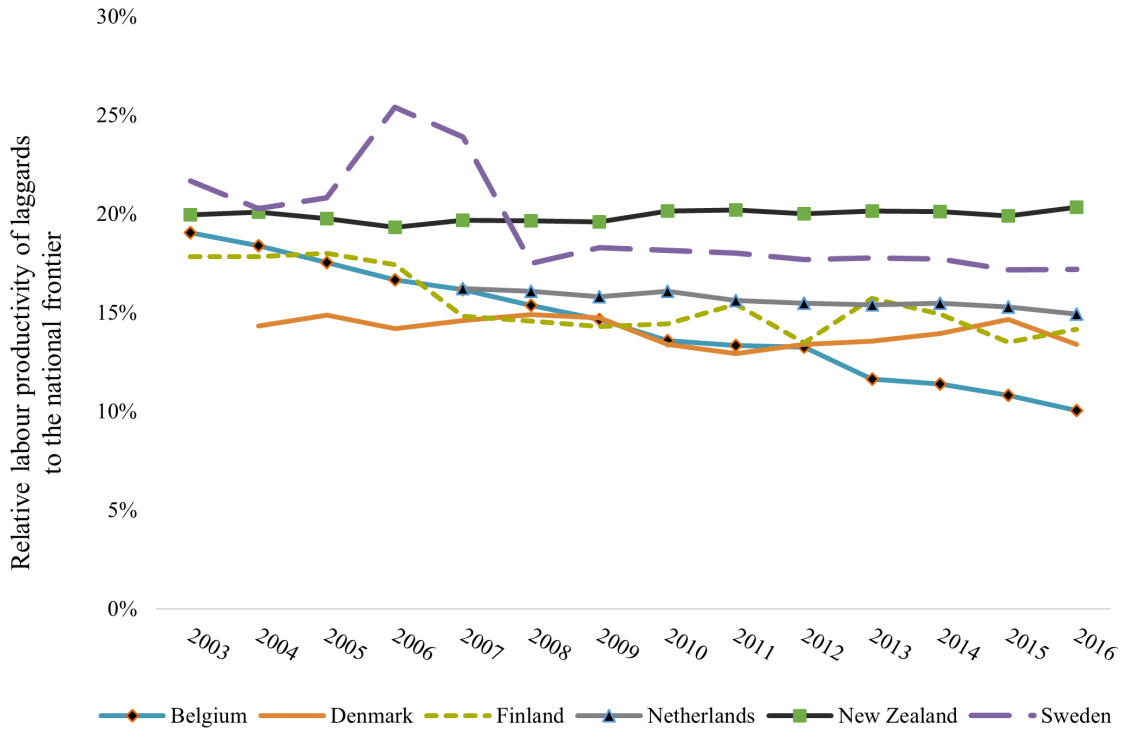
Chart 4 shows the relative labour productivity of the national frontier to the SAE frontier. Recall that the SAE frontier is the weighted average of the Industry SAE frontiers. This chart, therefore, illustrates cross-country productivity gaps.

It is evident that the national frontier in New Zealand not only has the largest productivity gap to the SAE frontier, but this gap has been widening over time. In 2003, the relative labour productivity ratio was 48 per cent. This has deteriorated to 45 per cent by 2016. Chart 4 also shows that there was a substantial decline in relative labour productivity for New Zealand around the time of GFC, in 2008. From the data behind the graph we know that this was because the SAE frontier grew at a faster rate than New Zealand's national frontier.

Chart 4 shows that the productivity gap to the SAE frontier has also widened for Finland, and to a smaller extent, Denmark. In comparison, it has decreased for Belgium, most notably since 2012.

We next focus on within-country productivity gaps, by assessing the relative labour productivity between laggards and frontier

Chart 5: Relative Labour Productivity of Laggards to the National Frontier, 2003-16



Source: Authors' calculations using CompNet.

firms for each of the six SAEs. As Chart 5 shows, the productivity dispersion between the top and bottom deciles of New Zealand's labour productivity distribution remained relatively stable over the sample period of 2003 to 2016. This is consistent with the evidence thus far suggesting that these two types of firms grew at a slow and similar rate over this time period, 0.5 per cent for laggards and 0.6 per cent for frontier firms. This picture is in contrast to the widening within-country productivity gaps for the majority of the comparator SAEs – particularly Belgium. This is likely driven by negative productivity growth on average across laggards in comparator SAEs, relative to strong positive productivity growth on average across frontier firms in these economies.

For New Zealand, a relative ratio of approximately 20 per cent (as evident in Chart 5) indicates that on average, its national frontier firms were approximately five times more productive compared to firms in the bottom 10 per cent of the productivity distribution. This productivity gap is smaller compared to New Zealand's SAE counterparts. This potentially suggests better within-country technology diffusion relative to the other SAEs. However, it should be noted that other research has found marginally larger productivity

19 Multiprod is a cross-country micro-aggregated productivity database managed by the OECD. Similar to CompNet, OECD adopts the "distributed microdata approach" (Berlingieri, Blanchenay, Calligaris, 2017) which distributes a standardized STATA routine through a network affiliated researchers and national statistical offices with access to confidential firm-level data and creates highly harmonized and comparable sets of cross-country database.

gaps, which place New Zealand closer to the OECD average. Papa *et al.* (2018) using OECD MultiProd[19] data find the 90-10 ratio of labour productivity to be 6.3 and 8.1 for the manufacturing and service sectors respectively, for New Zealand in 2011.[20] This compares to the 90-10 labour productivity difference of 5 found here.[21]

Therefore, it is best to conclude that depending on data (source, treatment, and coverage), New Zealand's within-country productivity gap ranges between being somewhat smaller to similar to the comparator SAEs.

Modelling the diffusion process

To quantify the cross-country and within-country technology diffusion processes we use the analytical framework described in Exhibit 1. We model the change in labour productivity (LP) for firms not at the SAE frontier and employ the following equation:

Equation 1: Productivity convergence model

$$\Delta LP_{cipt} = \alpha_1 \Delta frontier_{it}^{SAE} + \alpha_2 \Delta frontier_{cit}^{Country} + \beta_1 Gap_{cipt-1}^{SAE-Country} + \beta_2 Gap_{cipt-1}^{Country} + \epsilon_{cipt}$$

$$\epsilon_{cipt} = \lambda \epsilon_{cipt-1} + \gamma_{cip} + \sum_{j=1}^{3} yr^j + \omega_{cipt}$$

All variables are expressed in natural logs and measured at the country c, industry i, percentile p and year t level. In each combination of country-industry-year, we measure productivity levels at the 90th, 75th, 50th, 25th and 10th percentiles. The key benefit of having several productivity percentiles allows good coverage of the entire productivity distribution and improves the accuracy of regression estimations.

In this equation, the change in annual labour productivity of a firm not at the SAE frontier is modelled as a function of change in labour productivity at the SAE frontier and national frontier ($\Delta frontier_{it}^{SAE}$ *and* $\Delta frontier_{cit}^{Country}$); the lagged productivity gap between the SAE frontier and national frontier ($Gap_{cipt-1}^{SAE-Country}$); the lagged productivity gap within a country between frontier and non-frontier firms ($Gap_{cipt-1}^{Country}$); and the residual term ϵ_{cipt}. The residual term controls serial correlation (ϵ_{cipt-1}), fixed-effects (γ_{cip}), time trends[22] ($\sum_{j=1}^{3} yr^j$) and noise (ω_{cipt}). The fixed-effects impose a long-run conditional productivity convergence.[23] It implies that firms operate with different technologies and capabilities (e.g., managerial quality, human capital) and this will lead to different growth paths conditional on their steady-state productivity

20 The 90-10 ratio is the ratio of average labour productivity of frontier firms relative to laggard firms.

21 Several of the key differences between Multiprod and CompNet are discussed in Ivas *et al.*, (2020) and relate to differences in industry coverage and outlier treatment.

22 It includes linear, quadratic and cubic time trends to incorporate the common business cycle among countries.

23 Barro *et al.* (1991), Barro and Sala-i-Martin, (1992) Sala-i-Martin, (1996) extensively studied the concepts of absolute and conditional convergence at the macro level. They pointed out that the conditional convergence and the absolute convergence will coincide, only if all the economies have the same steady state. A Hausman test is applied to the model with and without fixed-effects and suggest the fixed-effects model return consistent estimates.

Table 8: Regression Estimates on Productivity Convergence Models

Variables	All	New Zealand	Other SAEs
β_1: Cross-country diffusion	0.047***	0	0.062***
	-0.007	-0.007	-0.008
β_1: Within-country diffusion	0.175***	0.233***	0.168***
	-0.019	-0.053	-0.02
Observations	3004	583	2421
R-squared	0.725	0.622	0.729
ρ	-0.165	-0.182	-0.182

Notes:
1. Estimates are based on the model specification (1).
2. Standard errors are clustered at the country-industry-percentile level, and reported in parenthesis.
3.***, ** and * denote statistical significance at the 1%, 5%, and 10% levels respectively.
4. ρ is the estimated serial correlation in the residual term.
Source: Authors' calculations using CompNet.

equilibria.

The third and fourth terms in equation are the key variables of interest in this study. $Gap_{cipt-1}^{SAE-Country}$ is the labour productivity gap between the SAE frontier and a national frontier, lagged one time period. The coefficient, β_1, therefore provides the impact of an increase in the productivity gap between the SAE frontier and national frontier on a non-frontier firm's labour productivity growth. It captures the long-run speed of (conditional) productivity convergence to the SAE frontier. $Gap_{cipt-1}^{Country}$ is the productivity gap between the national frontier and non-frontier firms. Its corresponding coefficient, β_2, captures the long-run speed of productivity convergence to the country's national frontier. Often, β_1 and β_2 are described as proxy measures of the effects of cross-country and within-country technology diffusion, ie, quantifying the processes described by the two arrows in Exhibit 1 respectively.

Empirical results

Results from the model specified in equation (1) are provided in Table 8. In all specifications, the estimated within-country diffusion is greater than the estimated cross-country diffusion. For example, based on the results in the first column for the full sample, a 1 per cent increase in the gap between the SAE frontier and the national frontier is associated with 0.05 per cent labour productivity growth for non-frontier firms in the following year. The corresponding estimate for within-country diffusion is a 0.18 per cent increase in labour productivity growth for non-frontier firms.

These findings are analogous to many international studies (Andrews *et al.*, 2015; Bartelsman *et al.*, 2008), suggesting that the diffusion process is expensive and difficult to transmit over distance.[24] Many international frontier technologies are highly tacit and non-codified and are not available

24 Note that improvements in digital communication in recent years may have shrunk the distance barrier. However, it should also be noted that rather than overcoming the distance between New Zealand and the rest of the world, "digital technologies have increased the returns to scale and agglomeration. Most digital innovation and its commercialisation occur in other countries, and proximity to innovation centres is increasingly important for firms and entrepreneurs." (Australian Productivity Commission and New Zealand Productivity Commission, 2019).

Table 9: Regression Estimates on Productivity Convergence Models by Macro-Sector

	Cross-country diffusion		Within-country diffusion	
Variables	New Zealand	Other SAEs	New Zealand	Other SAEs
Manufacturing	0.144*	0.082***	0.673***	0.260***
	(0.09)	(0.02)	(0.13)	(0.05)
Construction	(0.01)	0.059***	0.463***	0.305***
	(0.01)	(0.02)	(0.13)	(0.05)
Wholesale & Retail	-0.011*	0.058***	0.114*	0.149***
	(0.01)	(0.01)	(0.07)	(0.03)
Transportation & Storage	0.03	0.157***	0.428***	0.345***
	(0.03)	(0.03)	(0.11)	(0.06)
Accommodation & Food	-0.153**	0.01	0.02	0.428***
	(0.11)	(0.04)	(0.06)	(0.07)
Information & Communication	(0.07)	0.163***	0.505***	0.425***
	(0.12)	(0.05)	(0.15)	(0.07)
Real Estate & Rental Services	0.07	0.125**	0.384***	0.250***
	(0.06)	(0.06)	(0.14)	(0.06)
Professional Services	0.276***	0.129***	0.485***	0.183***
	(0.06)	(0.02)	(0.10)	(0.04)
Administrative Services	0.02	0.071**	0.736***	0.141**
	(0.02)	(0.03)	(0.11)	(0.06)

Notes:
1. Estimates are based on the model specification (1).
2. Standard errors are clustered at the country-industry-percentile level, and reported in parenthesis.
3. ***, ** and * denote statistical significance at the 1%, 5%, and 10% levels respectively.
Source: Authors' calculations using CompNet.

to all firms.

When comparing the productivity convergence exhibited by New Zealand versus the comparator SAEs, we find that they have similar speeds of technology diffusion within the country. However, in terms of cross-country diffusion, New Zealand has a statistically insignificant coefficient on $Gap^{SAE-Country}_{cipt-1}$. This finding, which is consistent with Harris (2020)[25] , suggests the breakdown of technology diffusion from the SAE frontier to New Zealand.

We next allow for heterogenous impacts of technology diffusion across different industries by separately estimating equation (1) for each of the nine macro-sectors in New Zealand, as well as the comparator SAEs. The results of this exercise are portrayed in Table 9 and there are a number of insights provided:

- Regardless of macro-sector, the same pattern from Table 8 is evident in Table 9, i.e., within-country diffusion is always greater than cross-country diffusion.
- In New Zealand's macro-sectors, there is a heterogenous pattern in terms of cross-country diffusion.

25 Harris (2020) used firm-level panel data in New Zealand and estimated production functions for 37 industries between 2001 and 2016. He finds that New Zealand frontier firms are not keeping up with global frontier firms, i.e. limited evidence of productivity convergence.

There are insignificant estimates for the sectors of construction; transportation storage; information communication; real estate rental services; and administrative services. Whereas, there is evidence of cross-country productivity convergence in both manufacturing, as well as professional services, with stronger convergence in the latter of these sectors.

- There is evidence of within-country diffusion across all macro-sectors in New Zealand except for accommodation and food. Furthermore, in all sectors except for accommodation and food and wholesale and retail, the levels of within-country diffusion are stronger than the comparable estimates for other SAEs.

Overall, the findings from Table 9 highlight that New Zealand firms are not receiving the economic benefits from the "best" technologies across the SAE frontier.[26]

Resource allocation

The third and final research objective in this study is to review the allocation of resources (labour and capital) across the productivity distribution in New Zealand and SAEs. Allocative efficiency is the extent to which production inputs (labour or capital) are optimally allocated across firms. International evidence suggests that reallocation of labour and/or capital inputs from less productive firms towards more productive firms provides a significant contribution to aggregate productivity growth (Melitz and Polanec, 2015; Petrin and Sivadasan, 2011). For example, Hsieh and Klenow, (2009) investigated the extent of resource misallocation in China and India, compared to the United States in the manufacturing sector. In a simulation whereby China and India moved to the U.S. dispersion of marginal products, total factor productivity was estimated to rise by between 30-50 per cent in China and 40-60 per cent in India.

Recent New Zealand research found that if resource misallocation was eliminated, total factor productivity would increase by more than a third (Meehan, 2020). This research also found that resource allocation had improved over the 2000s in both the manufacturing and service sectors, while it had deteriorated in the primary and utilities sectors. Meehan (2020) argued that many small firms with low productivity are larger than is optimal, signalling a poor 'up-or-out' dynamic for low productivity New Zealand firms.

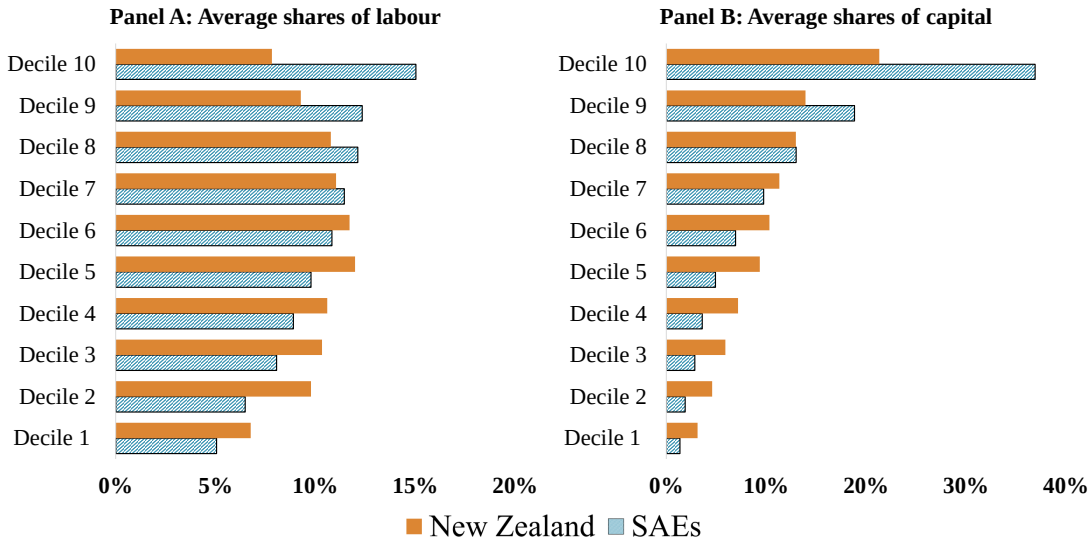
In this section, we further contribute to the resource allocation literature for New Zealand, with a focus on comparing the extent of (mis)allocation to that in other SAEs using the CompNet data.

Descriptives

To begin with, we present a graphical representation of the distribution of labour and capital across labour productivity deciles for New Zealand and the other SAEs. Panel A and Panel B in Chart 6 show labour and capital shares respec-

26 There are a number of factors that could play a role in poor cross-country diffusion for New Zealand. In Appendix B, we briefly highlight differences in participation in GVCs, which is a possible factor to be empirically investigated in future research.

Chart 6: Average Shares of Labour and Capital by Labour Productivity Deciles in New Zealand and Small Advanced Economies, 2003-16



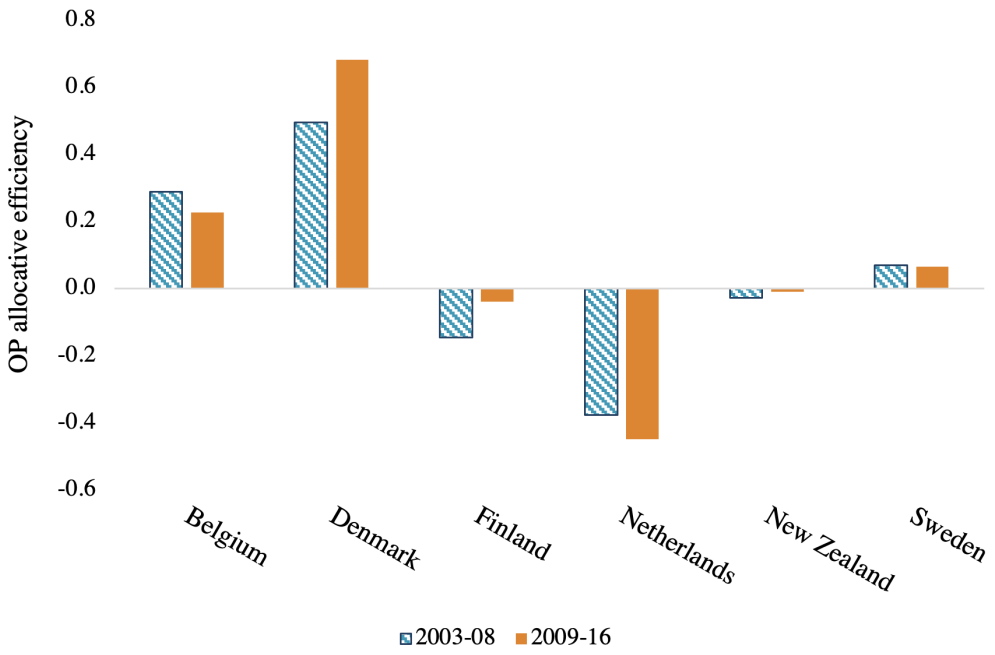
Notes:
1. Decile 1 is the lowest labour productivity decile, and Decile 10 is the highest labour productivity decile.
2. SAEs include Belgium, Denmark, Finland and Sweden.
3. For the SAEs, capital is defined as total values of tangible fixed assets, such as land, machinery and equipment. For New Zealand, capital values are measured as flows of capital services used by firms including depreciation, rental and leasing cost and cost of borrowing
Source: Authors' calculations using CompNet.

tively. In terms of the labour allocation, New Zealand has a disproportionally large concentration of employment in the middle productivity deciles. Firms in labour productivity decile 3 to 6 employ 45 per cent of total employment. The comparable figure is 38 per cent for SAEs on average. New Zealand firms at the top end of the productivity spectrum (deciles 8, 9, and 10) encompass 28 per cent of total employment. In comparison, SAE firms in those top three deciles account for 40 per cent of total employment. These findings point to potential labour misallocation in New Zealand.[27]

In terms of the distribution of capital, Chart 6 presents a clear monotonic positive relationship between labour productivity and capital shares for both New Zealand and the other SAEs. This relationship shows more capital at firms with higher labour productivity. For example, frontier firms (decile 10) account for 36 per cent and 48 per cent of total capital within New Zealand and SAEs respectively; whereas at the other end of the productivity distribution, capital at laggard firms (decile 1) accounts for 3.1 per cent and 1.4 per cent respectively. While the pattern across productivity deciles is similar for New Zealand compared to SAEs, the positive relationship between capital share and labour productivity is amplified for SAEs, indicating that capital allocation is marginally inefficient in New Zealand, in comparison.

27 A similarly poor labour allocation pattern was found by Meehan (2020) who split the data by labour productivity quartiles, rather than deciles.

Chart 7: Average Allocative Efficiency Across Small Advanced Economies



Note:
1. Allocative efficiencies are separately estimated by industries and aggregated to the national level by the industry population weight.
Source: Authors' calculations using CompNet.

Allocative Efficiency

Given the findings above, we focus on the allocation of labour in this analysis. To summarize the distribution of labour shares into a single statistic, we apply the productivity decomposition method introduced by Olley and Pakes (1996):

Equation 2: Olley-Pakes productivity decomposition

$$Y_t = \sum_i W_{it} Y_{it} == \overline{Y}_t + \sum_i (W_{it} - \overline{W}_i)(Y_{it} - \overline{Y}_i)$$

where W_{it} and Y_{it} are employment share and labour productivity at the firm-level, and a bar over a variable ($\overline{W_t}$ and $\overline{Y_t}$) represents the unweighted average of the firm-level measure. This decomposition separates weighted labour productivity (Y_t) into unweighted labour productivity ($\overline{Y_t}$) and the covariance term between firm size and labour productivity, $\sum_i (W_{it} - \overline{W}_i)(Y_{it} - \overline{Y}_i)$. The latter term is the measure of allocative efficiency. It reflects the extent to which more productive firms have greater labour shares, and vice versa. A positive allocative efficiency indicates that more productive firms are larger. If the statistic is zero this is equivalent to the allocation of labour across productivity deciles being random. A negative allocative efficiency is a sign of labour misallocation as less (more) productive firms have disproportionally large (small) employment shares.

Chart 7 presents allocative efficiency for New Zealand and comparator SAEs for the time periods of 2003-08 and 2009-16. Denmark, Belgium and Sweden, all have positive allocative efficiency. Denmark stands out as its allocative efficiency improves over

time from 0.495 in 2003-08 to 0.682 in 2009-16. These estimates can be interpreted in the following way – over the period 2009-16, labour productivity in Denmark was 68 per cent higher than it would be if labour was randomly allocated across firms. At the other end of the scale, Netherlands exhibits the worst allocative efficiency, -0.38 in 2003-08 and falling further to -0.45 in 2009-16. Its labour productivity would be 45 per cent higher if labour was randomly allocated.

For the case of New Zealand, allocative efficiency in both the pre- and post GFC periods is very close to zero. As explained earlier, this suggests that the allocation of labour across firms is the equivalent to a random distribution across labour productivity deciles. Note that Meehan (2020) finds a worse picture for allocative efficiency with respect to labour productivity in New Zealand. The estimate in that analysis improves marginally over the period 2001 to 2011 to end at approximately -0.25. The difference between the Meehan estimate and our finding in Chart 7 is likely due to differences in data treatment and industry coverage. Importantly though, neither our analysis using CompNet data nor the other available evidence provide a positive story regarding labour allocation in New Zealand.

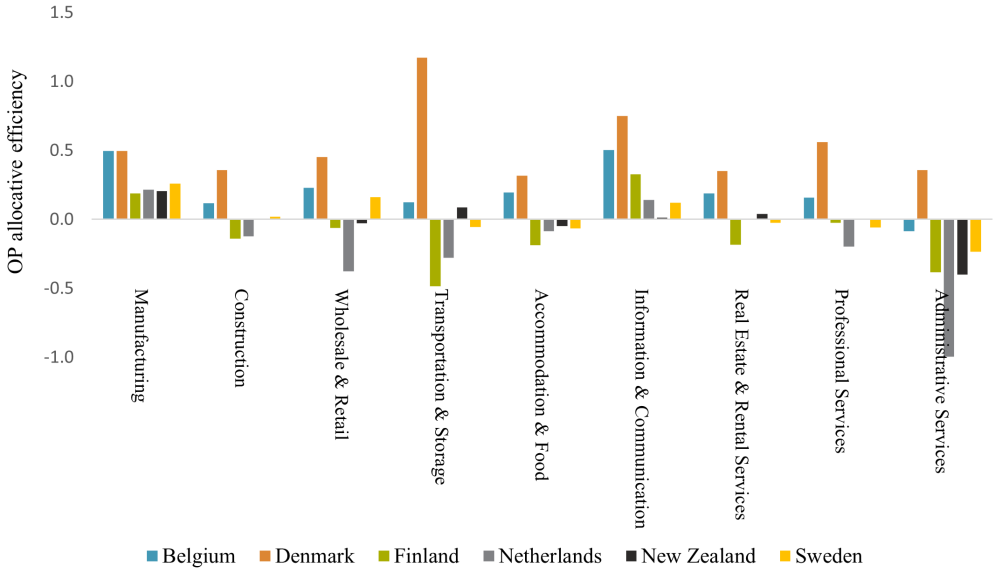
We next disaggregate the allocative efficiency results at the national level to the macro-sector level (Chart 8). Most macro-sectors in New Zealand exhibit weak positive, negative, or close to zero allocative efficiency. The administrative and support services industry appears to have the worst allocation of labour. Labour productivity is 41 per cent lower in this industry compared to the case of a random distribution of labour across firms in this sector.

The one exception to the general picture of misallocation of labour across industries in New Zealand is the manufacturing sector. Labour productivity is 21 per cent higher than it would be if labour was randomly allocated across firms. This finding accords with recent research by Meehan (2020) which found that manufacturing was one of two sectors where resource allocation improved in New Zealand over the 2000s.[28] While our results are not broken down by time, manufacturing does stand out as the one sector with relatively better performance in terms of labour allocation for New Zealand. Note of course that our performance in this sector is still well below that by Belgium and Denmark (50 per cent higher productivity than if labour was randomly allocated across firms) but is on par with the other SAEs of Finland, Netherlands, and Sweden.

The general pattern in allocative efficiency by industry in Chart 8 is broadly similar to international evidence on this front, which finds better resource allocation in manufacturing compared to services. This accords with the hypothesis that many services face less competitive pressures compared to the manufacturing sector. For example, Andrews and Hansell (2019) find negative and close to zero al-

28 Meehan (2020) also found the allocative efficiency estimate for manufacturing was greater than that for the service sector for the time period of 2001 to 2011.

Chart 8: Average Allocative Efficiency Across Small Advanced Economies, by Industry



Note:
1. Allocative efficiency for the real estate and rental services in the Netherlands is not available.
Source: Authors' calculations using CompNet.

locative efficiency for administrative services and accommodation and food, for Australia over the period 2002-16. This is also the case for the majority of SAEs in our analysis, except Denmark. These industries are generally domestically focussed, face less trade exposure and thus lower competitive pressure.

Counterfactual productivity gains in New Zealand

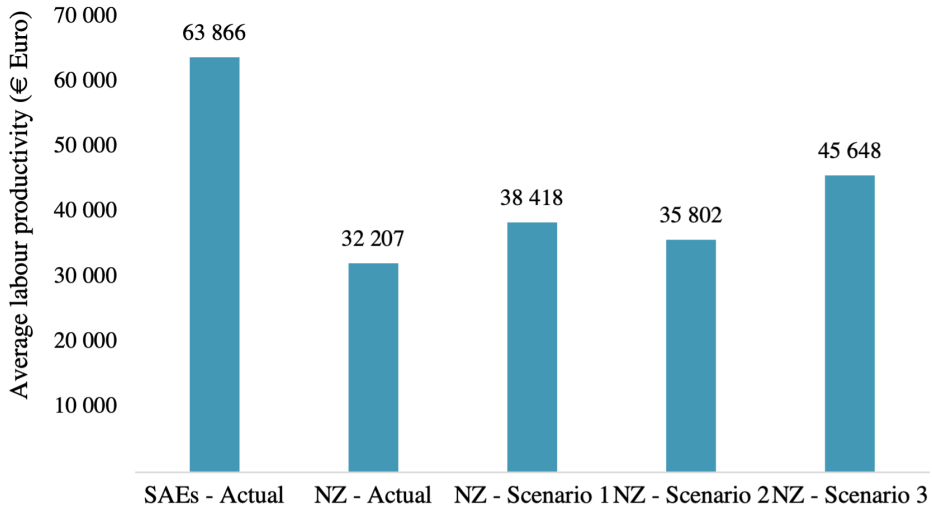
Analyses on productivity convergence and resource allocation in Sections 3 and 4 point to these factors contributing to New Zealand's poor productivity growth over the period 2003-16. We next use scenarios to quantify the possible productivity gains if improvements are made in technology diffusion and resource allocation. We construct three specific scenarios:

- Scenario 1: Improved cross-country technology diffusion results in firms at labour productivity deciles 9 and 10 in New Zealand becoming as productive as firms at productivity decile 9 and 10 firms in SAEs.
- Scenario 2: Labour allocation across the productivity deciles in New Zealand (Panel A in Chart 6) follows the same labour distribution as firms in SAEs.
- Scenario 3: Both scenario 1 and 2 occur.

It is important to note that these hypothetical scenarios are very simplistic. There is no consideration given to the policies that would be targeted towards these outcomes or any potential spillover effects on other aspects of the economy. The counterfactual analysis is based on using data over the period 2003-16, and thus is a historical simulation.

The first two bars from the left in Chart 9 shows the actual average labour productivity levels in New Zealand and the comparator SAEs over 2003-16. New Zealand's

Chart 9: Counterfactual Productivity Gains in New Zealand's Average Labour Productivity Level



Notes:
1. The first two bars show the average actual labour productivity over the 2003-16 period for New Zealand and the comparator SAEs. Average labour productivity is the weighted average of labour productivity at the macro-sector level.
2. For the SAE average, Denmark and Netherlands data start from 2004 and 2007 respectively.
3. Average labour productivity estimates are converted into a standard currency (Euros) and deflated by taking country-industry specific deflators and country-level PPPs from the Eurostat-OECD programme (2005 prices).
Source: Authors' calculations using CompNet.

average labour productivity is 32,207 euros across firms Euros per worker, approximately 53 per cent of the SAE average.[29] Under scenario 1, average labour productivity in New Zealand would rise to 38,418 euros per worker, a 19 per cent gain. Scenario 2 offers a smaller productivity boost of 11 per cent (up to 35,802 euros per worker). If both scenarios occur, the potential productivity gain escalates to 42 per cent, up to 45,648 euros per worker. In this final simulation, relative productivity would improve from 53 per cent to 71 per cent of the SAE average.

Conclusion

This article studies the productivity performance of New Zealand firms to five other SAEs (Belgium, Denmark, Finland, Netherlands and Sweden). To do so, we employ novel cross-country microdata from CompNet. Our research objectives are three-fold: (i) present stylized facts regarding productivity levels and growth rates for New Zealand relative to the comparator SAEs, including benchmarking laggard, median and frontier firms; (ii) evaluating the rate of technology diffusion and thus productivity convergence for New Zealand relative to other SAEs; and (iii) reviewing the allocation of resources (capital and labour) across the productivity distribution in New Zealand and SAEs.

New Zealand's average firm labour productivity hovered around 53 per cent of the average productivity level across other

29 This aggregate labour productivity in New Zealand is slightly higher than the one shown in Chart 1, as it is a weighted average, where weights are based on labour shares in the corresponding labour productivity decile. The aggregate labour productivity used in Figure 3.1 is the unweighted average of firm-level labour productivity.

SAEs over the period 2003 to 2016, with no sign of narrowing. This weak relative productivity performance was also evident in the majority of broad industry categories. In only three out of nine macro-sectors was there a marked improvement in relative productivity, and for only one of these sectors (Information Communication) was this driven by high positive productivity growth in New Zealand, rather than productivity declines in SAEs.

Productivity gaps between New Zealand median firms and their counterparts in SAEs were stable over time. Contrasting patterns are found for laggards and frontier firms. New Zealand's laggard firms show gradual improvements in relative productivity to their SAE counterparts, whereas New Zealand frontier firms are falling further behind their SAE counterparts. The relative productivity ratio of frontier firms has dropped from 53 per cent in 2003 to 40 per cent in 2016.

We provide an analytical framework for evaluating the rate of technology diffusion at the cross-country level (from the SAE frontier to national frontiers) and within-country level (from national frontier firms to non-frontier firms). While the speed of productivity convergence is similar at the within-country level between New Zealand and other SAEs, we find strong evidence to support the hypothesis of a broken diffusion machine at the cross-country level for New Zealand. This implies that New Zealand frontier firms are not receiving the economic benefits from the "best" technologies across the SAE frontier. This could be a result of one or more of geographic isolation from foreign markets, low levels of international trade, lack of participation in GVCs, a weak innovation system, or low capital intensity.

Review of resource allocation patterns for both labour and capital across the productivity distribution for New Zealand reveals misallocation of labour. New Zealand has a disproportionately large concentration of employment in less productive firms, particularly those in the middle of the labour productivity distribution. Furthermore, we estimate allocative efficiency as being close to zero, which suggests that the allocation of labour across firms in New Zealand is equivalent to a random distribution.

Our final empirical endeavour simulated the potential productivity gains possible if there was: (i) improved cross-country technology diffusion (resulting in firms at labour productivity deciles 9 and 10 in New Zealand becoming as productive as firms in comparable deciles in other SAEs); and (ii) improved labour allocation whereby New Zealand firms follow the same labour distribution as firms in SAEs. When both scenarios are imposed on the data, the labour productivity gain for New Zealand is 42 per cent, which equates to the country's relative productivity improving from 53 per cent to 71 per cent of the SAE average. Turning these hypothetical productivity simulations into reality and accelerating New Zealand's productivity performance will require learning lessons from many SAEs.

As explained in the draft report of "New Zealand firms: Reaching for the frontier" (2020), the New Zealand Productivity Commission recommends a greater focus on exporting specialized products at scale (to overcome New Zealand's hurdles

of size and distance); an overhaul of the innovation ecosystem; focussed government investment on areas of existing or emerging economic strength; and greater collaboration between government, industry and researchers on innovation policy and investments. In general, there are potential opportunities for New Zealand to set a clear innovation strategy and take deliberate steps to upgrade its innovation ecosystem, which in turn may hopefully "shift the dial" on productivity.

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Appendix A: Data Sources and Time Coverage

Country	Data sources	Time
Belgium	Bank of the Accounts of Companies Harmonised (BACH), European Committee of Central Balance Sheet Data Offices (ECCBSO)	2003-2017
Denmark	Accounts Statistics and general enterprise statistics	2004-2016
Finland	Structural business and financial statement statistics data	1999-2017
Netherlands	Statistics finances of non-financial enterprises and business register	2007-2017
New Zealand	Longitudinal Business Database and Integrated Data Infrastructure	2001-2017
Sweden	Structured business statistics, international trade in goods and business register	2003-2016

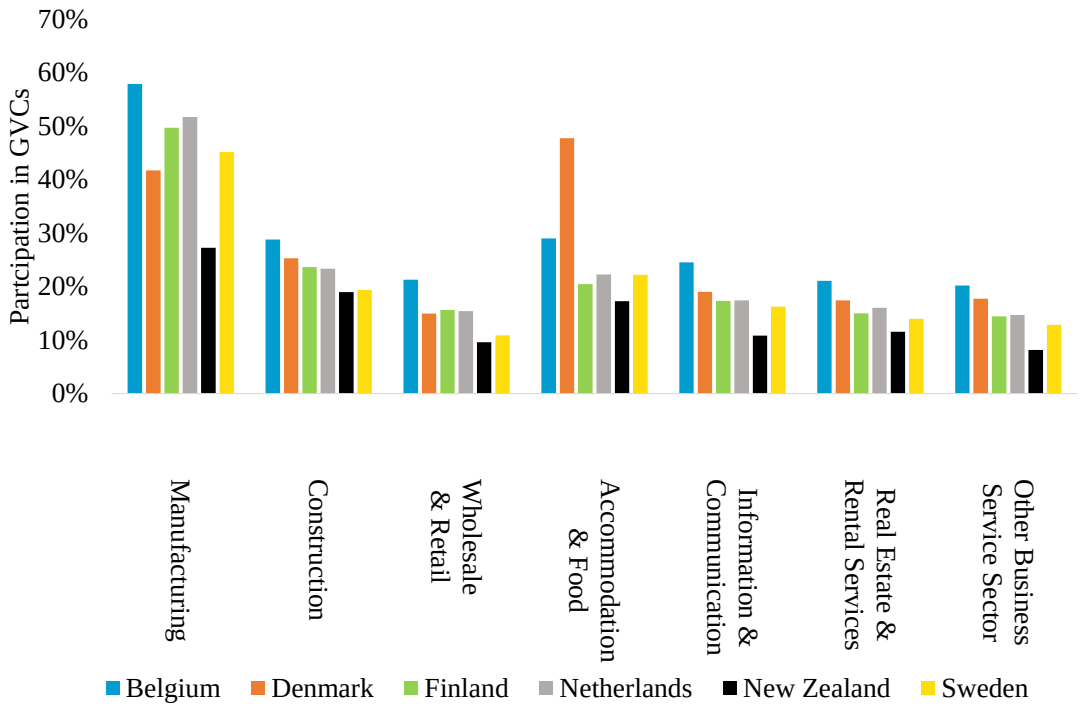
Note: Except for Belgium, all financial variables are constructed from firm-level data.

Appendix B: Participation in Global Value Chains

There are a number of factors that could play a role in the poor cross-country technology diffusion found for New Zealand firms. For example, de Serres *et al.*, (2014) suggests that remote access to markets and suppliers and low investment in innovation together account for between 17 to 22 percentage points of the 27 per cent productivity gap found with respect to the OECD average (based on 20 OECD countries). One factor to consider is the role of international integration, and in particular, participation in Global Value Chains (GVCs). GVCs comprise a wide range of value creation beginning from the development of a new concept to basic research, product design, the supply of core material or components, assembly into final goods, distribution, retail, after service and marketing (including branding). Taglioni Winkler (2016) describe a number of transmission channels whereby participating in GVCs can improve productivity and growth. For example sales of GVC-linked intermediates to the domestic market could push productivity in downstream activities. Similarly, GVC-linked consumption of local raw materials could prompt improved productivity in upstream activities. GVC participation could also spur investment in infrastructure, and allows a firm's specialisation in specific tasks, thus enabling easier access to international markets.

The Trade in Value Added (TiVA) database from OECD has a cross-country and cross-industry data on participation in GVCs. A country's participation in GVCs can be partially measured by how much of its exports are made with imported intermediate inputs (backward linkage) and how much of its exports are used as intermediate inputs by other countries to make their export goods and services (forward linkage). Appendix Chart 1 illustrates average participation levels in GVCs for all SAEs across the nine macro-sectors. It shows, that regardless of sector, New Zealand ranks the lowest in terms of participation in GVCs. Furthermore, in results not shown in this figure, for the majority of macro-sectors, New Zealand's participation has experienced a decline (albeit usually less than a 1 per cent drop) over the period of 2005 to 2015. This finding potentially signals that New Zealand's firms are becoming more disconnected from their customers and suppliers over time.

Appendix Chart 1: Participation in Global Value Chains, Average Between 2005 and 2015



Note:
1. GVC participation at the country and sector level is defined in terms of the origin of the value-added embodied in exports including both backward participation and forward participation from a reference country. It is a metric of engagement in the form of buying from (backward participation) and selling (forward participation) to GVCs.
Source: Trade in Value Added (TiVA), OECD.