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Editors' Overview

This 40th issue of the *International Productivity Monitor* (IPM) marks a major milestone in the development of the publication, with Ottawa-based Centre for the Study of Living Standards now partnering with The Productivity Institute in the United Kingdom. The IPM will now serve as the flagship publication of both organizations. Starting with this issue, Bart van Ark will join Andrew Sharpe as co-Editor of the IPM. Bart is a well-known international productivity researcher who recently assumed the position of Managing Director of The Productivity Institute. He is also a professor of Productivity Studies at the Alliance Manchester Business School at the University of Manchester in the UK.

This issue contains seven articles: Research articles address pay and productivity trends in Canada; the benchmarking of the productivity performance of frontier firms in New Zealand; the cause of Japan's economic slowdown; and the measurement of the volume of output and productivity in services industries in OECD countries. The issue also contains a viewpoint on why Canada needs an Equitable Growth Institute and review articles on books on techniques for the measurement of productivity and efficiency and productivity issues in the UK.

Governments, and society in general, are increasingly insisting that economic growth must be equitable in nature. A key feature of an inclusive growth path is that workers receive their fair share of productivity gains. In the lead article in the issue, **David M. Williams** from the Business Council of British Columbia provides a detailed examination of long-term productivity and pay trends in Canada. He finds that growth in the average real consumption wage has in fact more or less kept up with labour productivity growth over the 1961-2019 period, although there were divergences in sub-periods. This largely reflected the stability of labour's share of income.

New Zealand has long followed the market-oriented policy prescriptions given by international organizations. But it has seen no productivity payoff, ranking 25th out of 36 OECD countries in terms of output per hour growth since 2000. To shed light on this puzzle, the second article by **Guanyu Zheng** from the Reserve Bank of New Zealand, **Hoang Minh Duy** from the National University of Singapore, and **Gail Pacheco** from Auckland University of Technology and the New Zealand Productivity Commission compares the relative productivity performance of New Zealand's laggard, median, and frontier firms to those of five small advanced economies. Perhaps not surprisingly, New Zealand firms fare poorly, with the labour productivity of frontier firms less than half the average productivity of such firms in comparator countries. These firms appear not to be benefiting from the diffusion of best practice technologies.

After very rapid economic growth in the immediate postwar period, the Japanese economy entered a period of secular stagnation in the 1990s. The reasons for this economic stagnation are still not fully understood. In the third article in this issue, **Ky-**

oji Fukao from Hitotsuboshi University, **YoungGak Kim** from Senshu University, and **HyeogUg Kwon** from Nihon University use the Japan Industrial Productivity Database to shed light on the cause of Japan's economic slowdown. The authors identified the absolute decline in the size of the working age population (15-64), sluggish accumulation of capital, and weak investments in economic competencies, and a decline in TFP growth in a small number of industries, as the key culprits responsible for the slowdown in economic growth in 2005-2015 relative to 1995-2005.

Reliable volume estimates of output in service industries require accurate data on services prices to deflate nominal output measures. But do statistical offices in OECD countries measure services producer process in a consistent and reliable manner? In the fourth article, **Mary O'Mahony** from King's College London and **Lea Samek** from the OECD and King's College London address this issue through an audit of prices for 31 individual services activities posted on the websites of the national statistical offices in 16 OECD countries. They find a small but significant upward bias in prices for one widely used price measurement method, resulting in the underestimation of the volume of services output and productivity.

Many countries have a government-funded research body to promote productivity growth. Canada does not. In the fifth article, **Don Drummond** from the Centre for the Study of Living Standards and Queen's University makes that case that the government of Canada should establish an Equitable Growth Institute to address both the productivity challenge and the need for inclusive and environmentally sustainable growth.

In the sixth article, **Bert Balk** from Erasmus University discusses the volume *Measurement of Productivity and Efficiency: Theory and Practice* by Robin C. Sickles and Valentin Zelenyuk. He finds much to praise in the book, particularly its thoroughness. Balk notes a disconnect between productivity researchers in the neoclassical school, who assume firms act efficiently, and researchers in the data envelopment and stochastic frontier analysis field where the focus is on efficiency and the many ways to measure it. He wonders whether economists working with the first approach pay sufficient attention to the work of those using the second.

In the seventh article **Bart van Ark** from the University of Manchester and The Productivity Institute discusses two edited volumes recently produced by the UK Productivity Insights Network. The first volume addresses the nature and causes of the UK productivity slowdown from an interdisciplinary perspective. The second volume focuses on the implications of the pandemic for productivity. Many contributors argue for policy intervention to prevent permanent damage on productivity after the pandemic and create better conditions for a sustained productivity revival. Building on the insights from the 37 articles in the two volumes, the reviewer develops a detailed agenda for UK research and policy on productivity going forward.

Pay and Productivity in Canada: Growing Together, Only Slower than Ever

David M. Williams[1]
Business Council of British Columbia

Abstract

Pay and labour productivity growth in Canada are broadly aligned over the long run since 1961 and during the 2008-19 business cycle. The slowdown in Canada's productivity growth rate since 2000, the general stability of the labour share, and the lack of further gains in labour's terms of trade after 2008 largely explain the slowdown in workers' real pay growth over the 2008-19 business cycle. Canadians should be concerned about the country's persistently low productivity growth because it leads to low real pay growth. Canada's policymaking institutions should prioritize understanding and accelerating productivity.

This article examines the long-run relationship between growth in labour productivity, defined as real output per hour worked across the total economy ("productivity"), and growth in average workers' pay, defined as real hourly total labour compensation ("pay").[2] When both concepts are carefully measured, productivity and pay in Canada have broadly kept pace with each other in aggregate over the long run and across business cycles. The economy-wide link between growth in productivity and pay appears foundational and intact.[3]

The main contribution of this article is to present new evidence for Canada building on Sharpe *et al.* (2008a). In comparision with that study, and also Dufour and Russell (2015), Uguccioni *et al.* (2016) and the Canadian results in Harrison (2009) and Sharpe and Uguccioni (2017), this article uses: total economy average labour compensation (including supplemental labour income and the labour income of the self-employed) as the sole, comprehensive measure of nominal pay. To construct real pay,

1 Vice President of Policy at the Business Council of British Columbia. The author thanks Andrew Sharpe, Jock Finlayson, Ken Peacock and four anonymous referees for helpful comments, and Wulong Gu from Statistics Canada for providing historical data. Email: david.williams@bcbc.com.

2 Hereafter, "productivity" and "pay" refer to levels, and growth refers to their change over time. An acceleration (deceleration) in levels is an increase (decrease or slowdown) in growth rates.

3 The analysis does not consider changes in the distribution of pay across income groups, firms, regions, industries, skills, or socioeconomic characteristics. It is noteworthy that although income inequality did increase in Canada during the 1980s and 1990s, the Gini coefficients for market incomes and disposable incomes peaked in 1998 and 2004 respectively (Statistics Canada, 2021). In other words, Canada appears unlike the United States (Mishel and Gee, 2012) in that household income inequality has been declining for about two decades.

the study uses the household consumption expenditure deflator (HCE) in addition to the GDP deflator (PGDP) and the consumer price index (CPI). The study also excludes depreciation and output-based taxes from the measure of total economy output in labour productivity. Sharpe *et al.* (2008a) consider the five Canadian business cycles over 1961-2007 but the main analysis is focused on 1980-2005 which predates most of the boom in Canada's external terms of trade from 2002-08. This article examines a longer time period of 1961-2019 and includes six business cycles, including the 2008-19 cycle.

Sharpe *et al.* (2008a) concluded that hourly median real earnings of full-time workers deflated by the consumer price index (CPI) had lagged productivity by 1.26 per cent per annum during 1980-2005. They attributed about half of the gap to the incompleteness of the wage measure and an increasing gap between median and average earnings. By focusing solely on average total labour compensation (and comparing it to productivity which is also an average), this article does not consider those factors. Of the remaining gap, Sharpe *et al.* (2008a) attribute almost two-thirds to a decline in labour's terms of trade and the rest to a decline in the labour share (the ratio of nominal labour compensation to nominal output). The longer time period and measurement choices in this article provide new evidence about these relationships for Canada.

The structure of the article is as follows. The first main section surveys the literature. Section 2 sets out the neoclassical theory of the firm on the relationship between pay and productivity. Section 3 addresses measurement issues. Section 4 provides the results using annual Canadian data. Section 5 discusses the findings. Section 6 discusses the policy implications. Section 7 concludes. The Appendix provides data sources and descriptions.

Literature Review

The literature on the relationship between pay and productivity is vast. Two main strands are relevant to this article. The first considers what has happened to the labour share. Central to this question is the measurement of the numerator and the denominator, the time period, the countries considered, and whether the analysis is at the total economy, industry or firm level. The second concerns the relationship between real pay growth and labour productivity growth, which additionally must consider measures of prices and hours worked. If these relationships are stable over the long run, then the reasons for the post-2000 slowdown in productivity growth in Canada and elsewhere matter a great deal because of their implications for real pay growth and improvements in living standards.

Labour share

The stability of the labour share was once considered a "remarkable historical constancy" (Kaldor 1957:1) and "one of the most surprising, yet best established, facts in the whole range of economic statistics" (Keynes 1939:48).[4] In recent decades, certain measures of the labour share have been found to be in decline in the United States (Elsby *et al.*, 2013) and across countries (Karabarbounis and Neiman, 2014), eliciting concern from international agencies (OECD, 2018; IMF, 2017; and ILO, 2015). Various hypotheses have been advanced to explain this apparent decline: falling relative capital prices (Karabarbounis and Neiman, 2014); increased capital accumulation (Piketty and Zucman, 2014); the rise of "superstar" firms and "winner takes most" competitive dynamics (Autor *et al.*, 2020); and capital-biased technical progress and automation (Acemoglu and Restrepo 2018; Martinez, 2018), among others.

Other studies question whether the aggregate labour share has declined after accounting for the measurement of self-employment labour income (Gutierrez and Piton, 2020 across countries, and to some extent Elsby *et al.*, 2013 for the United States), the capitalization of intellectual property products (Koh *et al.*, 2020 for the United States), and imputed rents from owner-occupied housing across countries (Gutierrez and Piton, 2020; Rognlie, 2015). Rognlie (2015) further argues the denominator should be net value-added at basic prices, which is the approach used in this article, rather than gross value-added at market prices. Gutierrez and Piton (2020) find that after standardizing measurements of self-employment labour income and housing imputed rents across countries, the corporate sector's labour share only declined in the United States manufacturing sector and is otherwise stable across European Union countries and the United States economy excluding manufacturing.[5]

Pay and productivity

A second strand of literature explores whether real hourly pay growth and labour productivity growth have decoupled (e.g. OECD, 2018; Schwellnus *et al.*, 2017). Due to data limitations, studies frequently define pay as: median or average wages excluding non-wage benefits paid by employers (rather than total compensation); a proxy for median compensation (since no such series exists); or employee compensation (excluding the labour income of the

4 Both quotations refer to the net labour share in the total economy, the focus of this article. Other authors define the labour share as the ratio of labour compensation to (gross or net) value-added in the corporate sector to sidestep the question of how to account for the labour income of self-employed workers – which, fortunately, is a published series in Canada, unlike in other countries such as the United States. Since the late-1970s was a peak in the labour share, the starting point of the analysis can also matter when drawing conclusions about time trends.

5 Notwithstanding debate about what has happened to the aggregate labour share in the long run, there are complex and possibly transitory dynamics at the industry and firm level, particularly between firms and to a lesser extent within firms. For example, Kehrig and Vincent (2021) find that the decline in the United States manufacturing sector's labour share since the 1980s (a pivotal industry given the findings of Gutierrez and Piton, 2020) was due to the reallocation of value-added to highly productive, low-labour-share manufacturing firms whose labour shares fell as output expanded. These firms were able to charge premium prices relative to peer firms, suggesting demand-side forces at work. However, the drop in their labour share was reversed after 5-7 years, leading the authors to characterize such firms as "shooting stars" rather than "superstars". Gouin-Bonefant (2018) produces a model of "superstar" firms with low shares and high productivity where rising productivity dispersion shields such firms from wage competition, putting downward pressure on the aggregate labour share.

self-employed). Such considerations can materially affect the results.

Feldstein (2008) highlights the importance of focusing on total compensation rather than wages, and using a common price deflator for compensation and productivity.[6] Both recommendations are adopted in this article, as are the recommendations of Rognlie (2015) to exclude depreciation and output-based taxes from the measure of output in labour productivity.[7] Stansbury and Summers (2017) using United States data for 1973-2016 and Castle and Hendry (2009) using United Kingdom data for 1860-2004 find a roughly one-for-one long-run relationship between growth in average compensation and productivity. Similarly, Pessoa and Van Reenen (2013) find few signs of what they call "net decoupling" between productivity and average compensation growth in the United Kingdom or the United States over the past 40 years. As noted earlier, Sharpe *et al.* (2008a), Harrison (2009), Dufour and Russell (2015) and Sharpe and Uguccioni (2017) provide the evidence for Canada.

The Theoretical Link Between Pay and Productivity

To assess the relationship between pay and productivity, this article applies the neoclassical theory of the firm as set out in Sharpe *et al.* (2008b). The economy's total real output is given by the Cobb Douglas production function:

$$y = \frac{Y}{P_Y} = AL^{\alpha}K^{1-\alpha} \tag{1}$$

where y is real output and Y is nominal output. P_Y is the price of output, A is technology, L is labour (total hours worked), K is capital (hours of capital use).[8] Workers earn wages (labour compensation) while owners of the firm earn returns to capital. The shares of income earned by the factors of production sum to one and are α for workers (the labour share) and $1 - \alpha$ for firm owners (the capital share).

Firms hire workers (measured in hours) up to the equilibrium at which the extra nominal revenue generated from an extra hour of labour is equal to nominal cost of that labour, W. There are two key conceptual points here. First, W includes all forms of labour compensation and benefits paid by firms. Second, W includes the labour income of the self-employed as well as employees – just as the measure of output (Y) includes the output of both employees and the self-employed.

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6 Strain (2019) provides another useful discussion of measurement issues.

7 Spant (2003), Baker and Rosnick (2007) and Ross and Murray (2010) also argue that depreciation should be excluded from the measure of output.

8 The model relies on several strict assumptions, including: A is exogenous; returns to scale are constant ([0,1]), which means that doubling labour and capital doubles output, and that for each factor the average and marginal products are equal; diminishing marginal returns to factor inputs ($\alpha < 1$), meaning that adding either more labour or more capital to the production process yields incrementally fewer gains in output; and competitive product markets and factor markets, meaning that individual firms and workers cannot affect market prices and wages. Functional forms all have strengths and weaknesses (Paul, 2019; Miller, 2008). Future research could explore the application of constant elasticity of substitution (CES) or multi-sector (e.g. housing/non-housing) production functions.

Real product wage

Wages deflated by output prices gives the "real product wage", w_{prod}, where W is nominal hourly total labour compensation, P_Y is output prices, Y_L is nominal total labour compensation and is L hours of employment.

$$w_{prod} = \frac{W}{P_Y} = \frac{W \cdot L}{P_Y \cdot L} = \frac{Y_L}{P_Y \cdot L} \quad (2)$$

Labour productivity

Because of constant returns to scale, the average and marginal products of labour are equal. Labour productivity is therefore:

$$\frac{y}{L} = \frac{Y}{P_Y \cdot L} \quad (3)$$

Note that labour productivity and the real product wage use a common price deflator, P_Y, as emphasized by Feldstein (2008). The real product wage is therefore the measure of pay that should most closely align with productivity in the long run.

Labour share

The ratio between the real product wage (Equation 2) and labour productivity (Equation 3) is the labour share (Equation 4). This is the proportion of nominal output paid to labour as a factor of production. One minus the labour share is the compensation paid to firm owners (the capital share).

$$\begin{aligned}\frac{\textit{real product wage}}{\textit{labour productivity}} &= \left(\frac{Y_L}{P_Y \cdot L}\right) / \left(\frac{Y}{P_Y \cdot L}\right) \\ &= Y_L / Y\end{aligned} \quad (4)$$

Using the notation of Sharpe *et al.* (2008b), rearranging the equation (4) and letting $\Delta\%X$ denote the percentage change in variable X, growth in the real product wage can be restated as:

$$\begin{aligned}&\Delta\%\textit{real product wage} \\ &\quad = \Delta\%\textit{labour productivity} + \Delta\%\textit{labour share}\end{aligned} \quad (5)$$

Labour's terms of trade

Workers produce goods and services sold by firms at output prices, P_Y. Workers' output includes consumer and non-consumer goods and services, including domestic products and exports but excluding imports. Workers use their nominal wages to buy consumer goods and services, which include consumer imports, at consumer prices, P_C. The ratio between the price of workers' output and the price of consumption is labour's terms of trade (P_Y/P_C). Labour's terms of trade can shift due to changes in export prices and domestic non-consumer product prices relative to consumer import prices.

Real consumption wage

Another important measure of wages is the real consumption wage, w_{cons}. The consumption wage measures the real consumer purchasing power of hourly nominal compensation, W. Unlike the product wage (noting that w_{prod} is a function of P_Y not P_C), the consumption wage does not reflect the real capacity of firms to pay wages unless $P_Y = P_C$. The consumption wage is:

$$w_{cons} = \frac{W}{P_C} = \frac{Y_L}{P_C \cdot L} = \frac{Y}{P_Y \cdot L} \cdot \frac{Y_L}{Y} \cdot \frac{P_Y}{P_C} \quad (6)$$

where Y_L is nominal total labour compensation, P_C is the price of consumption goods and services, L is total hours worked, Y is nominal output and P_Y is the price of output. Labour productivity is $Y/P_Y L$, Y_L/Y is the labour share, and P_Y/P_C is labour's terms of trade.

Again using the notation of Sharpe *et al.* (2008b), in growth terms, the relationship is simplified to:

$$\begin{aligned}
&\Delta\% \textit{real consumption wage} \\
&\quad = \Delta\% \textit{labour productivity} + \Delta\% \textit{labour share} \\
&\qquad + \Delta\% \textit{labour's terms of trade} \\
&\quad = \Delta\% \textit{real product wage} \\
&\qquad + \Delta\% \textit{labour's terms of trade}
\end{aligned} \tag{7}$$

Finally, an alternative measure of the real consumption wage is calculated by deflating hourly nominal compensation by the Consumer Price Index (CPI) instead of P_C. Whereas the household consumption deflator (P_C) in the national accounts is based on a changing basket of goods and services bought by consumers, the Laspeyres-type CPI reflects prices for a fixed basket of goods and services. If and only if $P_C = P_{CPI}$, which would imply no substitution of products by consumers in response to relative price changes, would the two measures of real consumption wages be equivalent. Furthermore, since w depends on P_Y (not P_C or P_{CPI}), if and only if $P_Y = P_C = P_{CPI}$ would measures of real consumption wages align with labour productivity.

Measuring the Link in Practice

Three key measurement issues arise in assessing the long-run relationship between growth in real pay and total economy labour productivity:

- How to measure nominal wages;
- How to measure prices used to translate nominal wages into real wages; and
- Whether the output measure used in the calculation of labour productivity should be net of non-factor production costs.

Measuring wages

The measure of nominal hourly wages, W, must be comprehensive. It should include all types of compensation paid by the firm to workers for applying their time and skills to the production process. It should include the labour compensation of both employees and self-employed workers (excluding dividends and other capital income received as business owners) because the measure of output in labour productivity includes the output of both employees and the self-employed. Similarly, it should include the compensation of workers across all industries, including both the business and non-business sectors, since all of these labour inputs contribute to total economy output. Table 1 shows the four main wage measures available in Canada and their scope.

The Labour Force Survey (LFS) and the Survey of Employment, Payrolls and Hours (SEPH) are the most commonly cited wage data sources because they are published monthly with a short lag. However, neither includes supplementary labour income (SLI, also known as employers' social contributions). National Accounts (NA) wage

Table 1: Canadian Wage Data Sources and Their Scope

Data source	All forms of income?	All forms of work?	All industries?
	Includes supplementary labour income	*Includes self-employed*	*Includes business and non-business sectors*
Productivity Accounts (PA)	Yes	Yes	Yes
National Accounts (NA)	Yes	No	Yes
Labour Force Survey (LFS)	No	No	Yes
Survey of Employment, Payrolls and Hours (SEPH)	No	No	No

Note: Although the LFS collects data on labour force status and hours worked among employees and the self-employed, earnings data are in respect of employees only. In March 2020, Statistics Canada (2020:26) added questions to the LFS about compensation for the self-employed. The data are not yet public, however.
Source: Statistics Canada

data shows that SLI has become a much larger share of employers' cost of labour over time, increasing from 9 per cent to 14 per cent of compensation between 1981 and 2019 (Chart 1).[9] [10]

The most comprehensive wage data source is the Productivity Accounts (PA), which includes SLI and an imputation for the labour income of the self-employed based on LFS and Census data (see Maynard, 2005).[11] Self-employment has played a declining role in Canada's labour market as a share of employment hours worked and all jobs since about the mid-1990s (Chart 2, Panel A).[12] Chart 2, Panel B, shows self-employment compensation as a share of PA total labour compensation rose from about 5 per cent in 1981 to a peak of almost 8 per cent in 1996 but thereafter faded to only around 4 per cent in 2019. Like NA wage data, the PA wage data covers the total economy, including both the business sector and non-business sector (i.e. government and non-profit institution serving households).

In summary, since all labour inputs con-

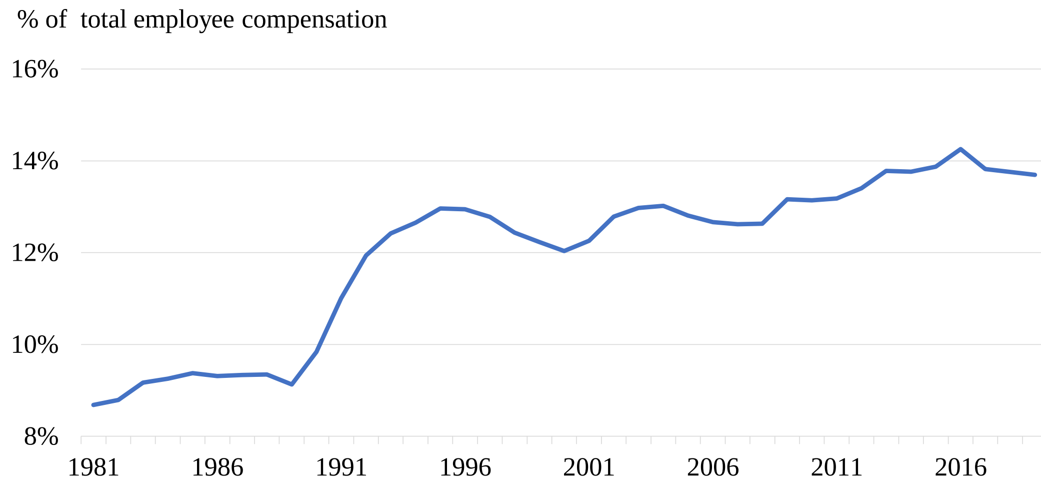
9 See definition of compensation in Statistics Canada (2016, Chapter 5). Champagne et al. (2017) highlight similar trends for the United States

10 For example, for the period 1966-86, employers contributed 1.8 per cent of their employees' income, up to the maximum annual pensionable earnings, to the Canada Pension Plan. The contribution rate was gradually increased to 4.95 per cent by 2003, and then began to increase again from 2019 and was 5.1 per cent in 2019. In inflation-adjusted 2019 dollars, the maximum annual employer contribution has increased from $615 CAD in 1966 to $2,748.90 CAD in 2019. That is a 347 per cent inflation-adjusted total increase in employers' contributions, which equates to a compound average growth rate (CAGR) of around 2.8 per cent per annum – which is well in excess of productivity growth.

11 Statistics Canada estimates labour compensation for self-employed workers as the sum of self-employment labour compensation by industry. Compensation in each industry is the product of the number of self-employed jobs, average annual hours worked by self-employed workers, and hourly total compensation rates. The number of self-employed jobs is estimated using quinquennial Census data that is then interpolated and projected using LFS data. Hours worked are primarily sourced from the LFS. Self-employed workers are assumed to earn the same hourly total compensation rate as employees in an industry.

12 Statistics Canada defines self-employed jobs as those held by unincorporated working owners, self-employed persons who do not have a business, and persons working in a family business without pay. Jeon and Ostrovsky (2020) highlight that close to half of tax filers citing self-employment income also report employee earnings (wages for which they received an end-of-year earnings summary, or T4 document, from their employer). For these individuals, most of their total income is employee income. In other words, for many self-employed workers, self-employment is not their main labour market activity.

Chart 1: Supplementary Labour Income (SLI) as a Share of Total Employee Compensation (excl. Self-Employed), National Accounts, Annual, Canada, 1981-2019



Note: SLI includes employers' contributions to: group or private pension plans; health, dental, life and other insurance policies; and government plans such as the Canada Pension Plan, Quebec Pension Plan, employment insurance, and workers' compensation insurance. National accounts labour compensation data exclude the self-employed.
Source: Statistics Canada Table 36-10-0221-01

tribute to output, the measure of pay should be similarly comprehensive. The PA provide the only complete source of wage data because they include all forms of labour income, all forms of work, and cover all industries. All other wage data are incomplete in some way and therefore miss important trends affecting compensation. LFS and SEPH consider money wages only and miss the rising proportion of compensation that employers pay to workers as SLI. SEPH data also exclude the non-business sector. Both PA and the NA wage data include SLI income and include all industries, but NA data excludes the labour income of the self-employed.

Measuring prices

There are three possible price indices that could be used to deflate nominal wages:

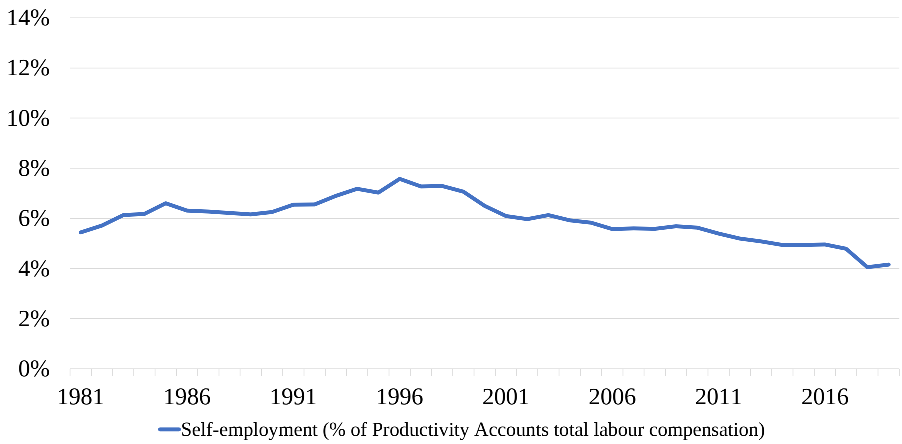
- Nominal wages deflated by output prices – i.e. the Fisher-type GDP deflator from the national accounts (PGDP) – gives the real product wage.[13]
- Nominal wages deflated by consumer prices – i.e. the Fisher-type household consumption expenditure deflator (HCE) from the national accounts – gives the real consumption wage.
- Finally, an alternative version of the real consumption wage uses the Laspeyres-type consumer price index (CPI) as the deflator.

13 In 2001, Statistics Canada switched from using Paasche to Fisher indices in the National Accounts and later recalculated historical series on that basis. Under certain conditions, a Paasche index can be thought of as the lower bound on prices changes while a Laspeyres index (because of its substitution bias) is the upper bound. The Fisher index lies in between, as it is the geometric average of the two.

Chart 2: Self-Employment as a Share of Hours Worked and all Jobs and Total Labour Compensation, Annual, Canada

Panel A: Share of Hours Worked and Share of All Jobs

Panel B: Share of Total Labour Compensation



Note: Self-employed jobs are those held by unincorporated working owners, self-employed persons who do not have a business, and persons working in a family business without pay. Panel A shows Labour Statistics consistent with the System of National Accounts for 1997-2019. Panel B shows the difference between Productivity Accounts labour compensation and National accounts labour compensation, as a share of Productivity Accounts labour compensation, for 1981-2019.
Source: Statistics Canada Tables 36-10-0489-01, 36-10-0221-01, 36-10-0480-01; author's calculations

Workers produce output sold at PGDP, which affects firms' marginal revenue product. Consumer prices (HCE or CPI) are not necessarily related to firms' revenues, such as for firms that export or sell products business-to-business or business-to-government. Therefore, neither HCE nor CPI necessarily influence firms' nominal resources with which to compensate factors of production. PGDP is thus the best available price index by which to assess the relationship between growth in real wages and productivity when applying the theory of the firm.

Workers use their wages to purchase consumer products. The real consumption wage is important to workers because it indicates changes in households' welfare as measured by real income. Here, the most appropriate price measure is HCE which is a subset of PGDP. Alternatively, CPI measures price changes for a periodically-updated fixed basket of goods and ser-

Table 2: Price Indices and Terms of Trade Over Canadian Business Cycles
Compound Annual Growth Rates (CAGR, Per Cent Change Per Annum), Annual Data

Business cycle	GDP deflator	Household consumption expenditure deflator	Consumer price index	Labour's terms of trade	Alternative labour's terms of trade	External terms of trade
Years	*PGDP*	*HCE*	*CPI*	*PGDP/HCE*	*PGDP/CPI*	*PX/PM*
A	B	C	D	E = B – C	F = B – D	G
1961-1973	4.36	3.50	3.40	0.86	0.96	0.57
1973-1981	9.43	9.30	9.26	0.12	0.17	0.19
1981-1989	4.70	5.11	5.16	-0.41	-0.46	0.11
1989-2000	1.96	2.11	2.21	-0.16	-0.25	-0.21
2000-2008	2.76	1.58	2.24	1.18	0.53	2.24
2008-2019	**1.30**	**1.29**	**1.60**	**0.01**	**-0.30**	**-0.68**
Long run:						
1961-2019	**3.85**	**3.57**	**3.72**	**0.27**	**0.12**	**0.30**

Note: PGDP is the GDP deflator, HCE is the household final consumption expenditure deflator, CPI is the consumer price index, PX is export prices and PM is import prices.
Source: Statistics Canada

vices.[14] It is the best-known price measure and is used by businesses and workers as an informal guide in wage and price setting, by governments to adjust tax brackets and benefits, and by the Bank of Canada in setting monetary policy.[15]

Table 2 sets out the compound annual growth rates (CAGR) for PGDP, HCE and CPI over the six Canadian business cycles from 1961-2019. Column A shows the business cycle dates as determined by the Business Cycle Council of the C.D. Howe Institute. Both 1961 and 2019 are starts and ends of business cycles, respectively. Also, the latest cycle, 2008-2019, is a complete cycle. Columns E and F show two measures of labour's terms of trade using HCE and CPI, respectively. Column G shows Canada's external terms of trade. The Appendix provides data sources. An online data appendix is available here [provide link].

Over 1961-2019, output prices rose by 3.9 per cent per annum while consumer price growth (HCE) was slightly lower, resulting in a 0.3 per cent per annum overall improvement in labour's terms of trade.[16] Notably, the 2000-08 cycle saw a strong rise

14 Statistics Canada updated the CPI basket weights in 1957, 1967, 1974, then mostly quadrennially (1978, 1982, 1986, 1992, 1996, 2001, 2005), then biennially from 2009 to 2017 (latest) based on household expenditure surveys (Statistics Canada, 2019: Appendix C). Note there is a long lag between the basket reference year and implementation of around three to six years before the 1996 update and about two years thereafter. For example, the 2015 reference basket was implemented in January 2017 and used until January 2019, when it was replaced by the 2017 basket.

15 Four main sources of divergence between the consumption deflator and the CPI are the formulae, relative weights on comparable items, treatment of medical expenses, and treatment of housing (see Johnson, 2017; and Pessoa and van Reenen, 2013:29-30, for the United States). Sabourin (2012) highlights four potential biases in the Canadian CPI: commodity substitution; outlet substitution; new goods; and quality (the latter can also be a challenge for HCE). Although Statistics Canada endeavours to account for these issues during updates of the basket, adjustments may still be imperfect. Sabourin (2012) estimates that mean total bias in the CPI is around +0.5 percentage points per annum relative to a true cost of living index.

16 There is incomplete overlap between the external terms of trade and labour's terms of trade. The external terms of trade is the ratio of export prices to import prices in respect of tradeable consumer and non-consumer goods and services. In labour's terms of trade, the numerator (PGDP) includes the prices of all tradeable and non-tradeable goods and services produced domestically, but the denominator (HCE) includes the prices for consumer goods and services only (including those that are imported).

in labour's terms of trade in part reflecting an extraordinary – but temporary – surge in Canada's external terms of trade. The latter resulted from a commodity price super cycle propelled by an accelerating Chinese economy (Buyuksahin *et al.*, 2016).

Chart 3 plots two versions of labour's terms of trade (PGDP/HCE and PGDP/CPI) and Canada's external terms of trade using 1961 as the base year. The two versions of labour's terms of trade are similar before the early 2000s. However, after the early 2000s, PGDP/CPI shows a much more muted rise until 2008, after which it gradually declines. PGDP/CPI appears to understate the improvement in labour's terms of trade by overstating the rise in consumer prices faced by households.[17]

Measuring labour productivity

Labour productivity is hourly real output (i.e. real GDP at market prices per hour worked). The question arises as to whether GDP overstates the income from production that is actually available to firms to compensate labour and capital as factors of production. National Accounts data shows depreciation costs have risen from around 14 per cent of nominal GDP before the mid-1970s to around 17 per cent in 2019 (Chart 4). It is generally accepted that the capital stock is depreciating at a faster rate because digital assets, intangible assets, and intellectual property have shorter lives (Spant, 2003). A rising proportion of output devoted to maintaining the capital stock means fewer resources are available to increase living standards (Baker and Rosnick, 2007).

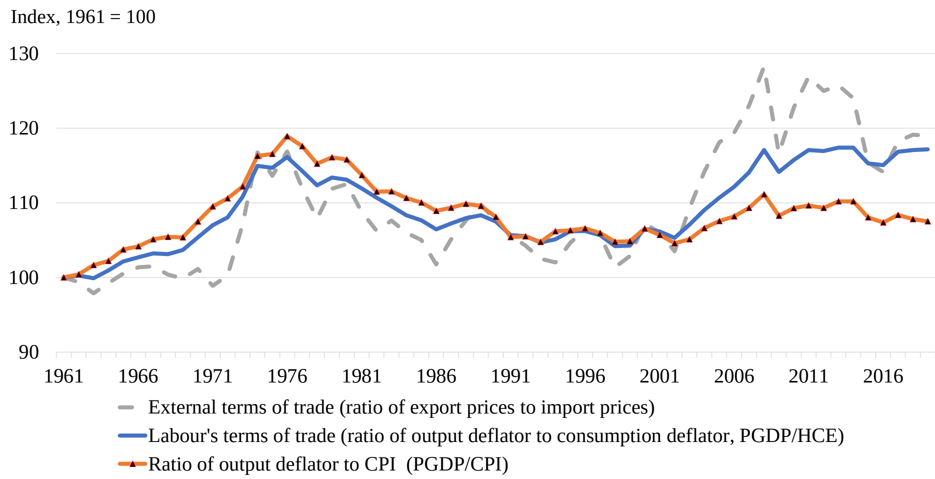
Two other non-factor production costs are "taxes less subsidies on products and imports" and "taxes less subsidies on production," which are tied to the value of output.[18]These production-based net taxes directly or indirectly influence the valuation of output, as distinct from taxes based on receiving income or possessing wealth. The sum of these taxes as a share of nominal GDP is similar in 2019 as compared to 1961, but has fluctuated widely in the interim (Chart 4). It fell sharply during the 1970s, rose significantly during the 1980s, and declined from 1993 to 2008. Since 2008, it has risen by about 1 percentage point of nominal GDP at market prices.

In total, non-factor production costs have increased from 25 per cent of GDP in 1961 to 28 per cent in 2019, with significant increases in the 1980s (partly reversed during the 1990s) and from the mid-2000s (Chart 4). The rise in non-factor pro-

17 Substitution effects missed by the CPI may have become more important from the 2000s due to the advent of cheap imports from China after its 2001 admittance to the World Trade Organization, internet shopping, e-commerce and dynamic pricing by firms. Another possibility is that there are differences in the treatment of housing in HCE and CPI that have become more important during Canada's post-2000 house price boom (Williams, 2018; Bergevin, 2012).

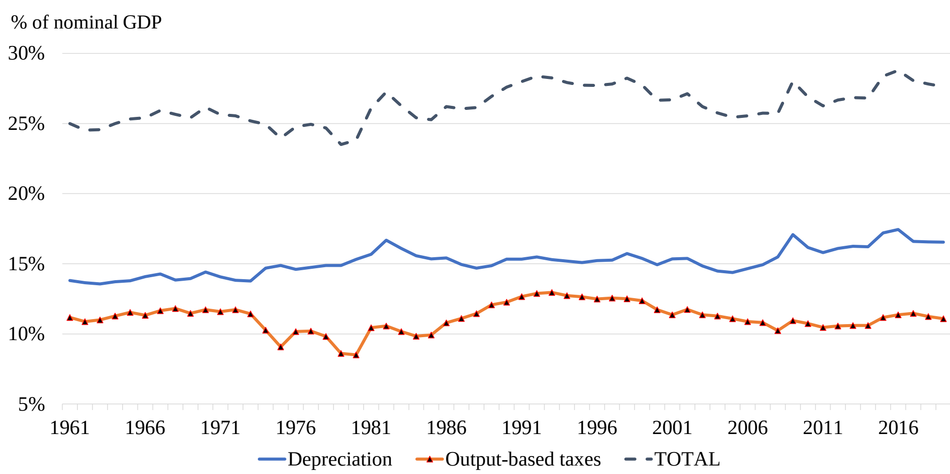
18 "Taxes less subsidies on products and imports" are collected from producers or importers directly as a percentage of the price of the traded product or as a dollar amount per physical unit. Examples include the goods and services tax (GST), harmonized sales taxes (HST) or provincial sales taxes (PST), import duties, export taxes, amusement taxes, air transportation taxes, municipal sales taxes, and environmental levies and excise on tobacco, alcohol or fuel. Taxes are remitted to the government when a product is sold: if no output is sold, no taxes are paid. "Taxes less subsidies on production" are taxes that are indirectly linked to production but must be paid by producers regardless of the level of profitability or sales. Examples include business property taxes, license fees, and taxes on pollution not linked to sales units. See Statistics Canada (2016, Chapter 4).

Chart 3: Labour's Terms of Trade and External Terms of Trade, Annual, Canada



Source: Statistics Canada Tables: 36-10-0129-01, 36-10-0130-01 and 36-10-0005-01

Chart 4: Non-Factor Production Costs, Per Cent of Nominal GDP at Market Prices, Canada, Annual, 1961-2019



Note: Depreciation is the sum of consumption of fixed capital for corporations, unincorporated businesses, and general government and institutions serving households. Output-based taxes include taxes less subsidies on products and imports, and taxes less subsidies on production.
Source: Statistics Canada Table: 36-10-0221-01

duction costs means GDP overstates the income from production firms have available to pay factors of production. An alternative nominal income measure is nominal net domestic product (NDP) at basic prices, which is defined in this paper as nominal GDP at market prices, less consumption of fixed capital, less taxes minus subsidies on products and imports, less taxes minus subsidies on production.[19] Real NDP at basic prices can only be estimated as a proxy because Statistics

19 The System on National Accounts defines output "at basic prices" as GDP at market prices less direct output-based taxes only. This paper removes both direct and indirect output-based taxes from the measure of output since neither is available to firms to compensate factors of production. For simplicity, hereafter this output concept is referred to as "at basic prices" to differentiate it from GDP at market prices.

20 An appropriate deflator for NDP at basic prices would exclude from output prices the price effects of depreciation and output-based taxes. This output price measure would be the most consistent with the theory of the

Canada does not produce a price deflator for NDP at basic prices.[20] This article relies on the GDP deflator as the price index for NDP, the same price deflator used for labour productivity and real product wages.[21]

Resolving measurement issues: Summary

In summary, the three measurement issues are resolved as followed:

- **Which measure of nominal wages?** PA data provide the only comprehensive source of nominal wage data. Other wage data sources (i.e. LFS, SEPH and NA) provide incomplete measures of total labour compensation because they do not capture SLI, the non-business sector, and/or the self-employed.
- **Which measure of prices to deflate nominal wages?** The most appropriate deflator to use in assessing the relationship between productivity and pay using the theory of the firm is the output price deflator. When assessing household well-being using the real consumption wage, the most appropriate price measure is the consumer price deflator (HCE), a subset of PGDP, while CPI is the least appropriate price measure because of substitution effects.
- **Is labour productivity the best measure of firms' income from production?** The conventional measure of output, GDP at market prices, overstates the resources firms have available to compensate labour and capital. A more appropriate measure of output is net domestic product (NDP) at basic prices which excludes depreciation costs and output-based taxes.

Results

Overview

Table 3 presents the results of the analysis using annual data for the six Canadian business cycles from 1961-2019. Chart 5 plots productivity growth and pay growth over the six Canadian business cycles corresponding to Columns A to F from Table 3. As noted earlier, the Appendix provides data sources and variable construction. An online data appendix is available here [provide link].

Long-run results

The bottom row of Table 3 shows the results for 1961 to 2019. Pay growth and productivity growth have roughly matched each other over the long run. Over 58 years, labour productivity growth averaged 1.7 per cent per annum and net labour productivity growth was 1.5 per cent per an-

firm (i.e. P_Y in equations 1-4 earlier) and in principle should be used to calculate net labour productivity and real product wages. In practice, a NDP deflator does not exist, so the GDP deflator is used as the measure of output prices. If overall price growth for depreciation and output-based taxes is slower (faster) than the GDP deflator, growth in net labour productivity and real product wages could be overstated (understated).

21 Ross and Murray (2010:25) also generate a proxy for real NDP (although theirs is at market prices). From real GDP at market prices they subtract an estimate of real depreciation (i.e. nominal depreciation deflated by an investment price deflator that they construct). However, this approach is problematic because Canadian real GDP data are chain-linked so are not additive.

Table 3: Productivity and Pay Growth Over Canadian Business Cycles
Compound Annual Growth Rates (CAGR, Per Cent Change Per Annum), Annual Data

Business cycle	Labour productivity	Net labour productivity	Real product wage	Real consumption wage	Alt. real consumption wage	Labour's terms of trade	Gross labour share	Net labour share
Years	*Real GDP at market prices /hour worked*	*Real NDP at basic prices /hour worked*	*Hourly compensation /PGDP*	*Hourly compensation /HCE*	*Hourly compensation /CPI*	*PGDP/HCE*	*Nominal compensation /Nominal GDP at mkt prices*	*Nominal compensation /Nominal NDP at basic prices*
A	B	C	D	E	F	G=E–D	H=D–B	I=D–C
1961-1973	3.11	3.30	2.97	3.83	3.93	0.86	-0.14	-0.33
1973-1981	1.80	0.59	1.50	1.62	1.67	0.12	-0.30	0.91
1981-1989	1.09	0.87	0.83	0.42	0.37	-0.41	-0.26	-0.04
1989-2000	1.56	1.65	1.23	1.07	0.97	-0.16	-0.33	-0.42
2000-2008	0.92	1.06	0.67	1.85	1.19	1.18	-0.25	-0.39
2008-2019	**0.99**	**0.69**	**1.05**	**1.06**	**0.75**	**0.01**	**0.06**	**0.36**
Long run: 1961-2019	**1.65**	**1.47**	**1.46**	**1.73**	**1.59**	**0.27**	**-0.19**	**-0.01**

Note: All data are for the total economy. Nominal net domestic product (NDP) at basic prices is nominal GDP at market prices less depreciation and output-based taxes. Real NDP is nominal NDP deflated by the GDP deflator (PGDP). HCE is the household final consumption expenditure deflator and CPI is the consumer price index. Total labour compensation and hours worked are from the Productivity Accounts, where compensation includes supplementary labour income and the labour income of the self-employed.
Source: Statistics Canada; author's calculations

num. Growth in real wages was similar: 1.5 per cent per annum for real product wage growth and 1.7 per cent per annum for real consumption wage growth. For the CPI-based real wage measure, growth was between at 1.6 per cent per annum.

Labour's terms of trade improved by 0.3 per cent per annum, indicating that worker's welfare improved as the prices of goods and services consumed by workers rose less than the prices of goods and services they produced. The gross labour share declined by 0.2 per cent per annum, indicating that workers received a slightly decreasing share of national income compared to capital providers. However, after accounting for non-factor production costs, which rose over the period, the net labour share was unchanged.

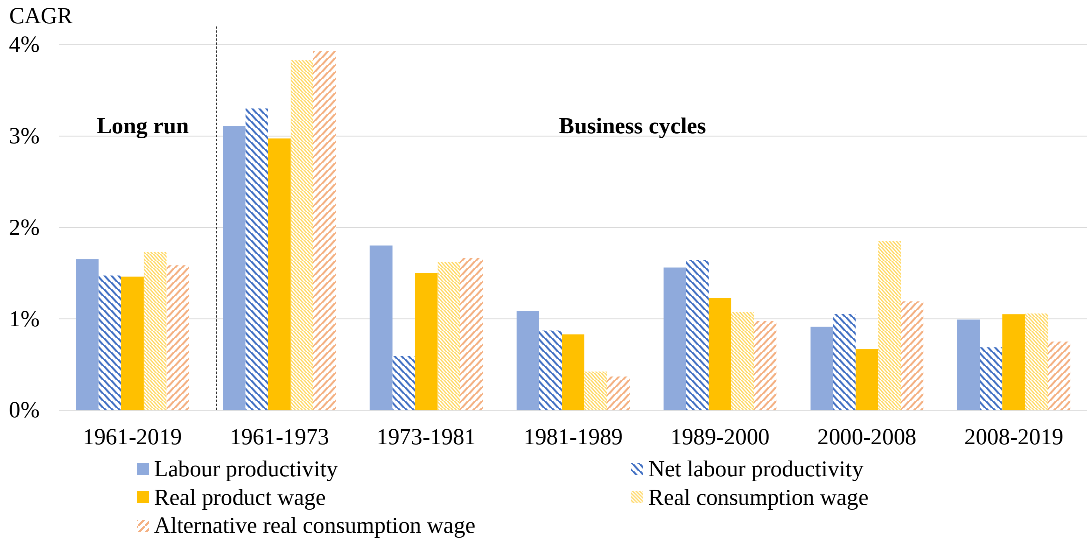
The 2008-2019 business cycle

The most recent business cycle from 2008-19, along with the 2000-08 cycle, saw the slowest productivity growth since records began in 1961. Labour productivity growth was 1.0 per cent per annum, while net labour productivity growth was even lower at 0.7 per cent per annum due to the increase in non-factor production costs.

Growth in productivity and pay was slow. Both the real product wage and the real consumption wage averaged around 1.1 per cent per annum, in line with labour productivity growth and slighty faster than net labour productivity growth. The CPI-based real wage measure was slightly lower at 0.8 per cent per annum, reflecting that the CPI rose faster than PGDP and HCE over the period.

The 2008-19 business cycle saw no change in labour's terms of trade, in stark contrast to the 2000-08 cycle when output prices significantly outpaced consumer prices. The gross labour share improved slightly by 0.1 per cent per annum. The net labour share improved by about 0.4 per cent per annum, reversing the decline that occurred over 2000-08. Overall, the main difference between the 2008-19 and 2000-09 business cycles is that households' real in-

Chart 5: Measures of Labour Productivity and Real Hourly Total Labour Compensation, CAGR (Per Cent Change Per Annum), Canada, 1961-2019



Note: Labour productivity is real GDP at market prices per hour worked. Net labour productivity is real NDP at basic prices per hour worked, where output excludes depreciation and output-based taxes. Total compensation per hour worked includes supplementary labour income and the labour income of the self-employed. Labour productivity, net labour productivity and the real product wage use the same price measure, PGDP. The real consumption wage and alternative real consumption wage use HCE and CPI, respectively.
Source: Statistics Canada and author's calculations

come was no longer aided by improvements in labour's terms of trade.

Discussion

Has pay kept up with productivity?

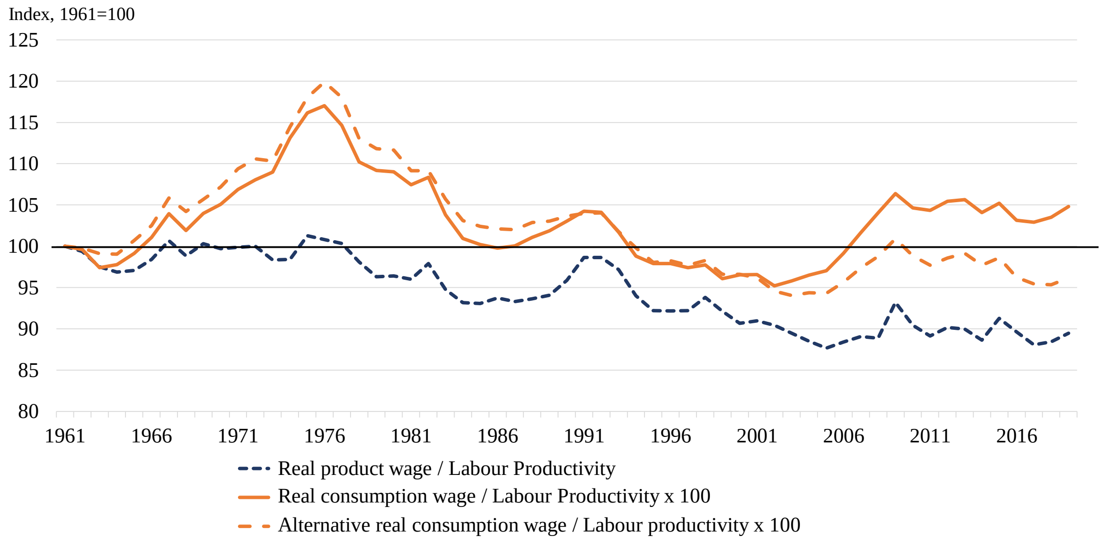
The question as to "whether pay growth has kept up with productivity growth in Canada" hinges to a large degree on measuring both concepts appropriately. Real product wages have lagged the conventional measure of labour productivity (Chart 6, Panel A). However, they tracked net labour productivity fairly well over 1961-2019 (Chart 6, Panel B). This is an important result. Consistent with the long run predictions of the theory of the firm, it suggests that workers received the full benefits of labour productivity gains after adjusting output for the rise in depreciation costs and output-based taxes.

Real consumption wages outpaced labour productivity for much of the 1961-2019 period (Chart 6, Panel A). They also significantly outpaced net labour productivity for almost the whole period (Chart 6, Panel B).[22] Both results reflect favourable movements in labour's terms of trade. Shifts in labour's terms of trade explain why real consumption wages rose faster than real product wages during 1961-73 and 2000-08. Nonetheless, changes in labour's terms of trade and the external terms of trade are generally temporary. Productivity growth is the only sure path to sustained gains in real pay and living standards over the long run.

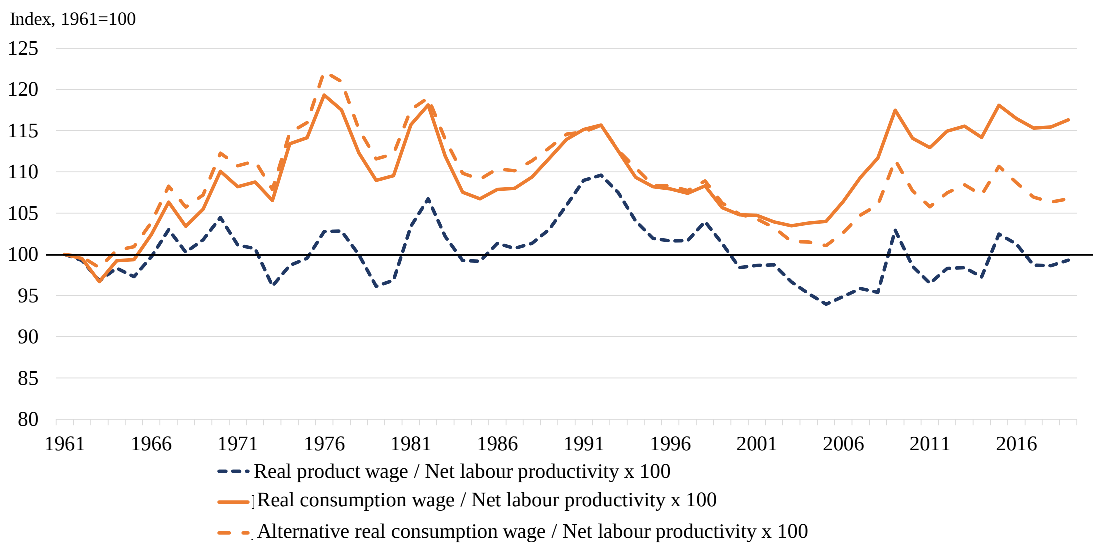
22 The alternative real consumption wage (based on CPI) lagged labour productivity from the 1990s (Chart 6, Panel A). However, it exceeded net labour productivity for almost the whole period, albeit by a lesser margin than the HCE-based real consumption wage (Chart 6, Panel B).

Chart 6: Ratio of Real Hourly Total Labour Compensation to Labour Productivity and Net Labour Productivity, Annual, Canada, 1961-2019

Panel A: Gross Productivity

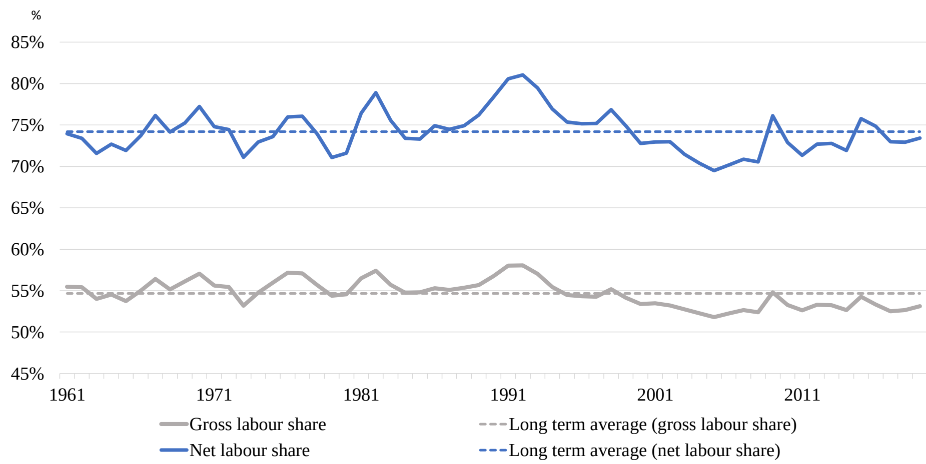


Panel B: Net Productivity



Note: Labour productivity is real GDP at market prices per hour worked. Net labour productivity is real NDP at basic prices per hour worked, where output excludes depreciation and output-based taxes. Total compensation per hour worked includes supplementary labour income and the labour income of the self-employed. Labour productivity, net labour productivity and the real product wage use the same price measure, PGDP. The real consumption wage and alternative real consumption wage use HCE and CPI, respectively.
Source: Statistics Canada and author's calculations

Chart 7: Gross and Net Labour Shares, Annual, Canada, 1961-2019



Note: Gross labour share is nominal total labour compensation / nominal GDP at market prices, where compensation includes supplementary labour income and the labour income of self-employed workers. Net labour share is nominal total labour compensation / nominal NDP at basic prices, where the denominator is nominal GDP less depreciation and output-based taxes.
Source: Statistics Canada and author's calculations

Has labour's terms of trade changed?

Canadian workers benefited from a significant 0.9 per cent per annum improvement in labour's terms of trade (PGDP/HCE) over the 1961-73 business cycle and a slight improvement over the 1973-81 cycle (Table 3, Column G). There was then a substantial deterioration over the 1981-89 cycle and to a lesser extent the 1989-2000 cycle. The 2000-08 cycle saw a strong 1.2 per cent per annum increase in labour's terms of trade, and then no change at all over the 2008-19 cycle. Both the 1961-73 and 2000-08 increases in labour's terms of trade were associated with increases in Canada's external terms of trade driven by commodity price booms (see Chart 3 and Table 2 earlier). Over the 2008-19 cycle, there were no further gains in labour's terms of trade and the surge in the external terms of trade began to unwind.

Has the labour share changed?

Chart 7 shows the gross and net labour shares. The net labour share was mostly above its long-run average over the two decades prior to 2000 and was mostly below it thereafter. By 2019, the net labour share was close to its long-run average and its 1961 level. Overall, the share of net income paid to labour appears little changed. Canadian data suggests that structural influences on the aggregate net labour share may play a minor role or cancel each other out in the long run, notwithstanding fluctuations across business cycles and complex dynamics at the firm and industry level.

Policy Implications

Since in the long run the net labour share appears broadly stable, and pay growth and net productivity growth are broadly aligned, it follows that Canada's productivity growth performance has important implications for living standards. Canada's productivity growth rate fell by about half after 2000 as did growth in real product wages (Table 4). Had real product wages during 2000-2019 grown at the same pace as net productivity growth over 1961-2000 (i.e. 1.8 per cent per annum instead of 0.9 per cent per annum), pay would have been around 21 per cent higher by 2019. In current dollars, this means Canadian workers' average total compensation in 2019 would have been around $8 CAD per hour higher in 2019, or about $13,550 CAD per annum.[23]

Most advanced countries also saw labour productivity growth slow significantly after 2000 to around 1.2 per cent per annum on average among G7 and OECD countries as seen in Table 4 below and in Sharp and Tsang (2018).[24] Gordon (2012) argues that information and communications technology (ICT) innovations during the third industrial revolution from about 1960-2005, and digital innovations in the fourth industrial revolution now underway, do not have the same potential to generate large, continuous gains in living standards compared to the "great inventions" of the second industrial revolution from 1870-1970. Brynjolfsson and McAfee (2011) and Mokyr (2014) are more optimistic that the recent productivity slowdown is temporary. Nevertheless, Canada's labour productivity growth performance ranked 21st out of 23 OECD countries (for which data are available) over 1970-2000 and 25th out of 36 OECD countries over 2000-19, according to OECD statistics. By 2019, on a purchasing power parity basis, the level of Canadian real GDP per hour worked was about 27 per cent lower than the United States, 21-22 per cent lower than France and Germany, and 10 per cent lower than the United Kingdom. Notwithstanding debates about the technological frontier, there would appear to be ample scope to raise Canada's productivity growth by adopting innovations already deployed by leading countries and firms (i.e. through capital investment, technological diffusion and "catch up").[25]

Schumpeterian models emphasize the role of innovation, competition and creative destruction and are central to understanding productivity growth and the economic growth process (Aghion and Howitt, 2006). Andrews *et al.* (2016) finds that after 2000 there was increasing productivity among global frontier firms (the top 5 per cent most productive firms in the world) but rising productivity dispersion between them and non-frontier firms. They suggest that a rise in "winner takes most" competition and slower diffusion of innovations from leading to non-leading firms, due to regulatory restrictions on competition, could be responsible for the post-2000 global pro-

23 These calculations are relative to actual total compensation of $37.35 CAD per hour (current dollars) and 1691 annual hours worked per job in 2019 from the Productivity Accounts.

24 By industry, the manufacturing sector appears to be a key contributor to the productivity slowdown in the U.S (Kehrig and Vincent, 2021 and Gutierrez and Piton, 2020) and Canada (Sharpe and Tsang, 2018).

25 What if Canada had matched the OECD's productivity growth after 2000 instead of lagging it? OECD net labour productivity growth could have been about 1.10 per cent per annum over 2000-19 assuming the same growth in non-factor production costs as in Canada over the period (i.e. 1.21 per cent less 0.12 per cent equals 1.10 per cent). If Canadian real product wages had similarly grown at 1.10 per cent per annum over 2000-2019 (instead of 0.84 per cent per annum), they would have been about 5 per cent higher by 2019. In current dollars, this means Canadian workers' average total compensation in 2019 would have been higher by around $1.70 CAD per hour or $2,900 CAD per annum.

Table 4: Post-2000 Slowdown in Productivity and Pay Growth
Annual Data, Canada and G7/OECD Countries

Measure	**Compound annual growth rate** (CAGR, % change per annum)		
Canada	**1961-2000**	**2000-2019**	**(2000-2019) - (1961-2000)**
Labour productivity	1.99	0.96	-1.03
Net labour productivity	1.78	0.84	-0.94
Real product wage	1.74	0.89	-0.85
Real consumption wage	1.90	1.39	-0.51
Alternative real consumption wage	1.90	0.94	-0.96
Other advanced countries	**1970-2000**	**2000-2019**	**(2000-2019) - (1970-2000)**
G7 labour productivity	2.38	1.16	-1.22
OECD labour productivity	n/a	1.21	-

Note: Labour productivity is real GDP at market prices per hour worked. Net labour productivity is real NDP at basic prices per hour worked, where output excludes depreciation and output-based taxes. Total compensation per hour worked includes supplementary labour income and the labour income of the self-employed. Labour productivity, net labour productivity and the real product wage use the same price measure, PGDP. The real consumption wage and alternative real consumption wage use HCE and CPI, respectively.
Source: Statistics Canada; OECD Statistics; author's calculations

ductivity slowdown. Gu (2019) considers Canadian micro-data on firm-level productivity and splits the data into the top 10 per cent most productive Canadian firms by industry and the rest. He finds the post-2000 productivity growth slowdown was due to a decline in innovation at Canada's top firms (which could indicate slower innovation diffusion from global frontier firms), a decline in innovation diffusion from Canada's most productive firms to other firms, and a decline in resource reallocation and business dynamism.

Canadian policy discussions on economic growth tend to be preoccupied with increasing GDP through labour supply. Increased immigration, population and labour supply do increase GDP but they have negligible overall impact on GDP per capita (Riddell *et al.*, 2016) and do not materially alter the age structure of the population over time (Robson and Mahboubi, 2018, Chart 4). In contrast, higher productivity has the advantage of raising workers' real incomes and GDP per capita. Thus, an economic growth strategy centred on raising productivity growth would be a better strategy than one focused on expanding the labour supply because it would generate the extra resources to support retired workers and fund other enhancements to the social safety net (such as in Green *et al.*, 2020).

Curing the productivity-related maladies weighing on Canada's economic performance both before and after 2000 will require policymakers to consider structural policy settings that encourage or discourage product market competition and innovation diffusion, business dynamism and creative destruction, resource reallocation, investment in capital and skills, and economies of scale. An institutions-based approach to solving Canada's productivity growth malaise could involve establishing an Australian-style national Productivity Commission as an independent government agency tasked with conducting public inquiries on microeconomic problems and reforms (Williams and Finlayson, 2021; Capeluck, 2016) or establishing a United Kingdom-style university-based Productivity Institute (van Ark and Venables, 2020). The public benefits of such an institution would easily exceed its costs.

Conclusion

The slowdown in real product wage growth in Canada since 2000 reflects the slowdown in net labour productivity growth over the same period. In and of itself, this might have given Canadian workers cause for alarm in respect of their standard of living. However, during 2000-08, there was an extraordinary but temporary rise in labour's terms of trade, in part reflecting a surge in Canada's external terms of trade. Workers' welfare as measured by real incomes actually improved over the 2000-08 business cycle because real consumption wages accelerated, even as productivity and real product wages decelerated. This unusual confluence of forces may have obscured and (for a little while) dulled the full ramifications of Canada's post-2000 productivity growth slowdown on workers' pay.

Over the 2008-19 business cycle, the chickens came home to roost. The absence of further improvements in labour's terms of trade to raise real consumption wages laid bare Canada's productivity growth problem. The post-2000 slowdown in real product wage growth does not reflect a decline in the labour share after accounting for the increase in non-factor production costs. In fact, the net labour share increased over 2008-19 and was little changed overall between 1961 and 2019.

Fundamentally, Canada's serially weak productivity growth, the general stability of the net labour share, and the lack of further gains in labour's terms of trade after 2008 mean there is little to drive long term growth in either real product wages or real consumption wages. To generate higher average real pay and living standards, Canada's policymaking institutions will need to prioritize understanding and accelerating productivity.

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Appendix: Data Sources and Variable Construction

Concept	Definition	Construction	Source
PRODUCTIVITY			
Labour productivity	Real GDP at market prices per hour worked, all industries	Actual, 1997-	Productivity accounts, Statistics Canada, Table: 36-10-0480-01 (formerly CANSIM 383-0033), annual, 1997- *Accessed: 18/8/2020*
		Backcast to 1961 using historical series growth rate	Statistics Canada historical series, provided by request, annual, 1961- *Accessed: 11/8/2019*
Net labour productivity	Net domestic product (NDP) at basic prices per hour worked, all industries (see note)	Nominal GDP at market prices less consumption of fixed capital less taxes minus subsidies on products and imports, less taxes minus subsidies on production, 1981-	National accounts, Statistics Canada, Table: 36-10-0221-01 (formerly CANSIM 384-0037), annual, 1981- *Accessed: 18/8/2020*
		Backcast nominal component series to 1961 using growth rates of annualized data	Table: 36-10-0103-01 (formerly CANSIM 380-0063), quarterly, 1961Q1- *Accessed: 1/12/2020*
	/ GDP deflator (as a proxy for NDP at basic prices deflator, which Statistics Canada does not produce)	See below	See below
	/ Hours worked for all jobs, all industries	See below	See below
TOTAL LABOUR COMPENSATION (NOMINAL)			
Total labour compensation per hour worked **(Productivity accounts)**	Total labour compensation for all jobs, all industries, nominal	Actual, 1997-	Productivity accounts, Table: 36-10-0480-01 (formerly CANSIM 383-0033), annual, 1997- *Accessed: 18/8/2020*
		Backcast level to 1961 using historical series growth rate	Statistics Canada historical series, provided by request, annual, 1961- *Accessed: 11/8/2019*
	/ Hours worked for all jobs, all industries	Actual, 1997-	Productivity accounts, Table: 36-10-0480-01 (formerly CANSIM 383-0033), annual, 1997- *Accessed: 18/8/2020*
		Backcast level to 1961 using historical series growth rate	Statistics Canada historical series, provided by request, annual, 1961- *Accessed: 11/8/2019*
PRICES			
GDP deflator (PGDP)	Implicit price deflator for GDP at market prices (Fisher-type price index)	Actual	National accounts, Table: 36-10-0130-01 (formerly CANSIM 380-0102), annual, 1961- *Accessed: 26/4/2021*
Household final consumption expenditure deflator (HCE)	Implicit price deflator for household final consumption expenditure (Fisher-type price index)	Actual	National accounts, Table: 36-10-0130-01 (formerly CANSIM 380-0102), annual, 1961- *Accessed: 26/4/2021*
Consumer price index (CPI)	CPI, all items (Laspeyres-type price index)	Actual	Table: 18-10-0005-01 (formerly CANSIM 326-0021), annual, 1961- *Accessed: 26/4/2021*
External terms of trade	Ratio of export prices to import prices	Actual	Table: 36-10-0129-01 (formerly CANSIM 380-0101), annual, 1961- *Accessed: 5/5/2021*

Appendix: Continued

Concept	Definition	Construction	Source
TOTAL COMPENSATION (REAL)			
Real product wage (PGDP-based)	Total labour compensation per hour / PGDP	N/a	N/a
Real consumption wage (HCE-based)	Total labour compensation per hour / HCE	N/a	N/a
Alternative real consumption wage (CPI-based)	Total labour compensation per hour / CPI	N/a	N/a

Note: The System of National Accounts defines output "at basic prices" as GDP at market prices less direct output-based taxes only (i.e. taxes minus subsidies on products and imports). This paper removes both direct and indirect output-based taxes from the measure of output since neither is available to firms to compensate factors of production. For simplicity, this paper refers to this output concept as "at basic prices" to differentiate it from gross or net output at market prices.

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.

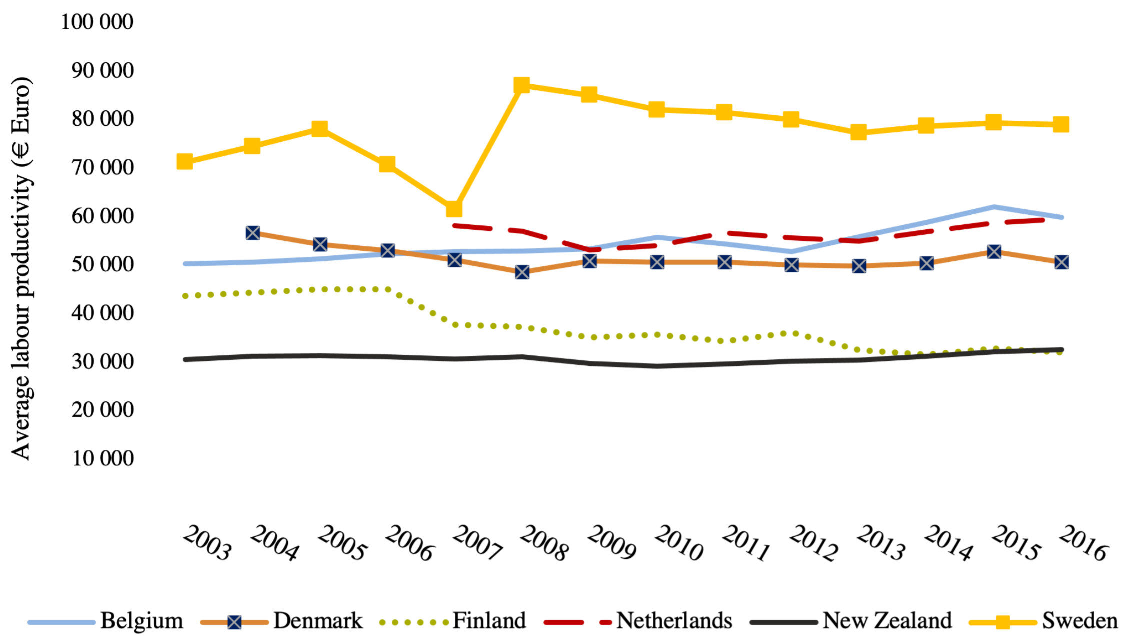
Productivity patterns

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.

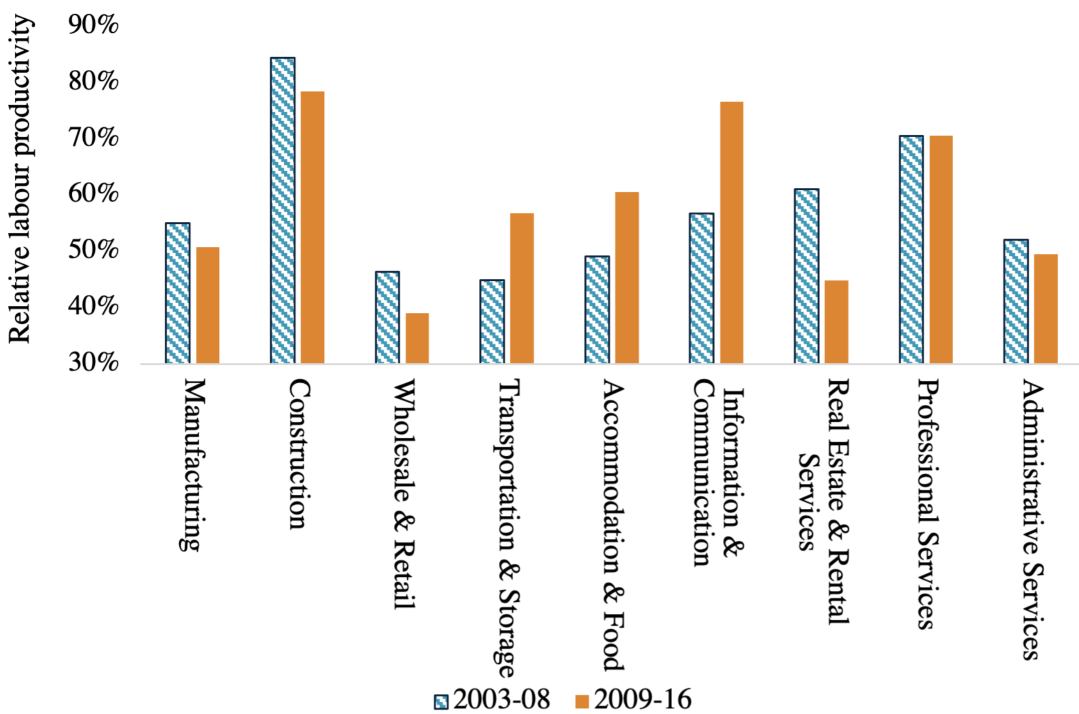
employee.

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.

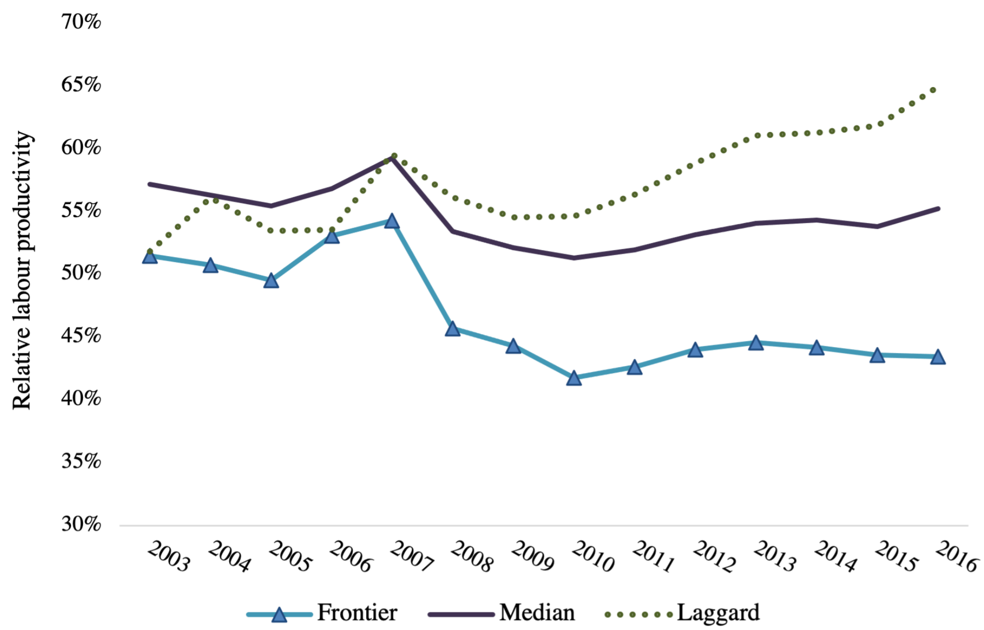
These insights highlight both positive and negative news - the converging trend for New Zealand laggards and the diverging trend for New Zealand frontier firms, relative to their SAE counterparts at the bottom and top of the labour productivity distribution, respectively.

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]

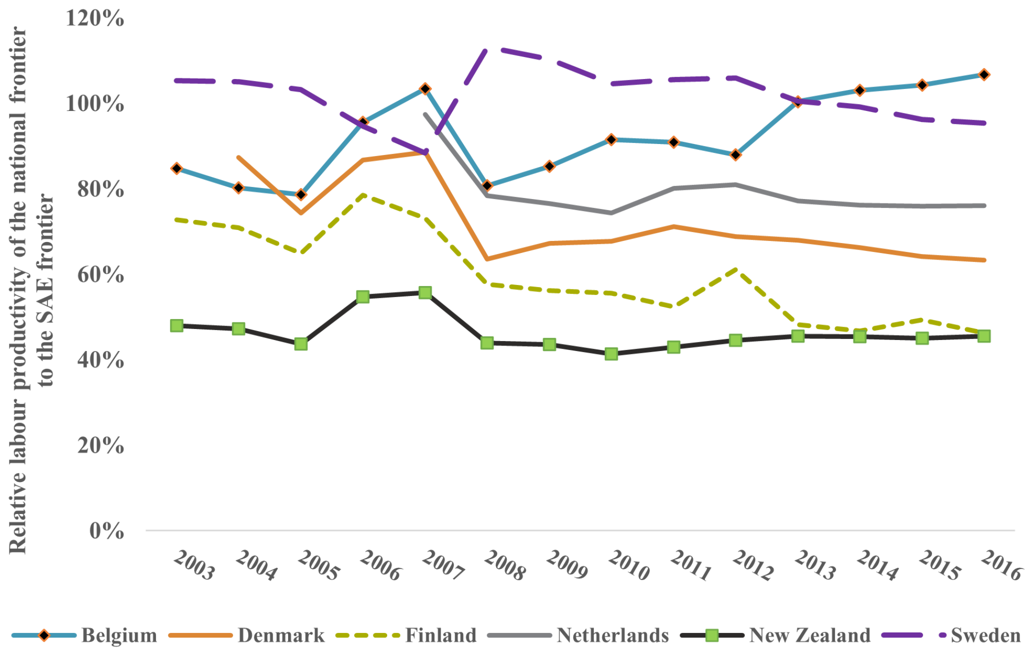
Technology diffusion can be defined as the process of transferring information, knowledge and innovation. The scope for technology diffusion from global frontier firms to non-frontier firms depends on several factors. This includes global connections, foreign direct investment (FDI), participation in 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

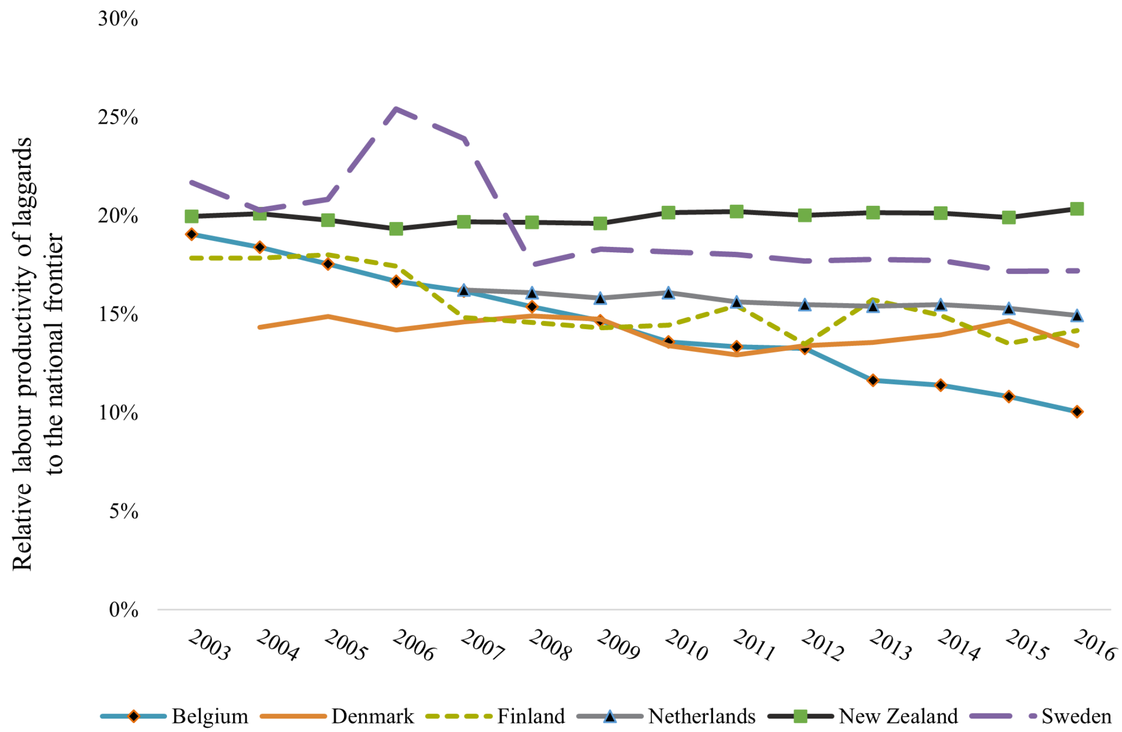
Chart 4 shows the relative labour productivity of the national frontier to the SAE frontier. Recall that the SAE frontier is the weighted average of the Industry SAE frontiers. This chart, therefore, illustrates cross-country productivity gaps.

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*** -0.007	0 -0.007	0.062*** -0.008
β_1: Within-country diffusion	0.175*** -0.019	0.233*** -0.053	0.168*** -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. $Gap^{SAE-Country}_{cipt-1}$ 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. $Gap^{Country}_{cipt-1}$ 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* (0.09)	0.082*** (0.02)	0.673*** (0.13)	0.260*** (0.05)
Construction	(0.01) (0.01)	0.059*** (0.02)	0.463*** (0.13)	0.305*** (0.05)
Wholesale & Retail	-0.011* (0.01)	0.058*** (0.01)	0.114* (0.07)	0.149*** (0.03)
Transportation & Storage	0.03 (0.03)	0.157*** (0.03)	0.428*** (0.11)	0.345*** (0.06)
Accommodation & Food	-0.153** (0.11)	0.01 (0.04)	0.02 (0.06)	0.428*** (0.07)
Information & Communication	(0.07) (0.12)	0.163*** (0.05)	0.505*** (0.15)	0.425*** (0.07)
Real Estate & Rental Services	0.07 (0.06)	0.125** (0.06)	0.384*** (0.14)	0.250*** (0.06)
Professional Services	0.276*** (0.06)	0.129*** (0.02)	0.485*** (0.10)	0.183*** (0.04)
Administrative Services	0.02 (0.02)	0.071** (0.03)	0.736*** (0.11)	0.141** (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.

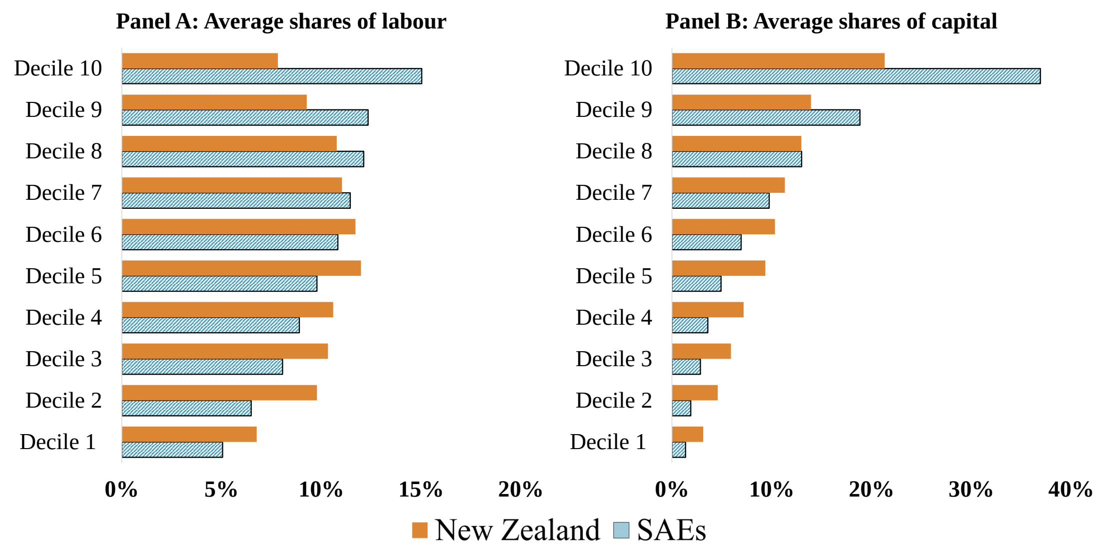
In this section, we further contribute to the resource allocation literature for New Zealand, with a focus on comparing the extent of (mis)allocation to that in other SAEs using the CompNet data.

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

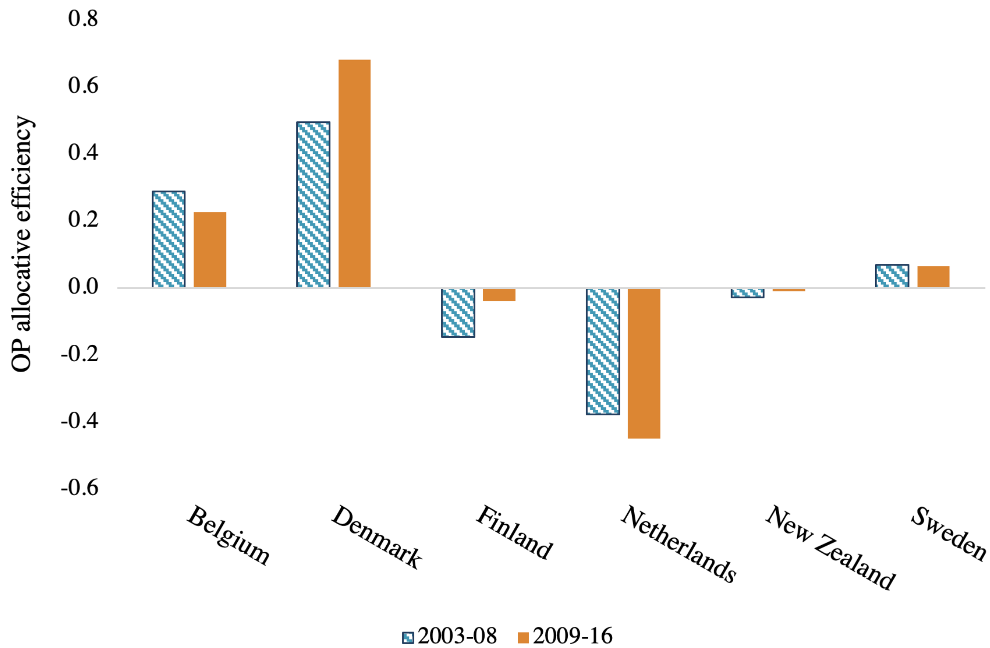
Source: Authors' calculations using CompNet.

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.

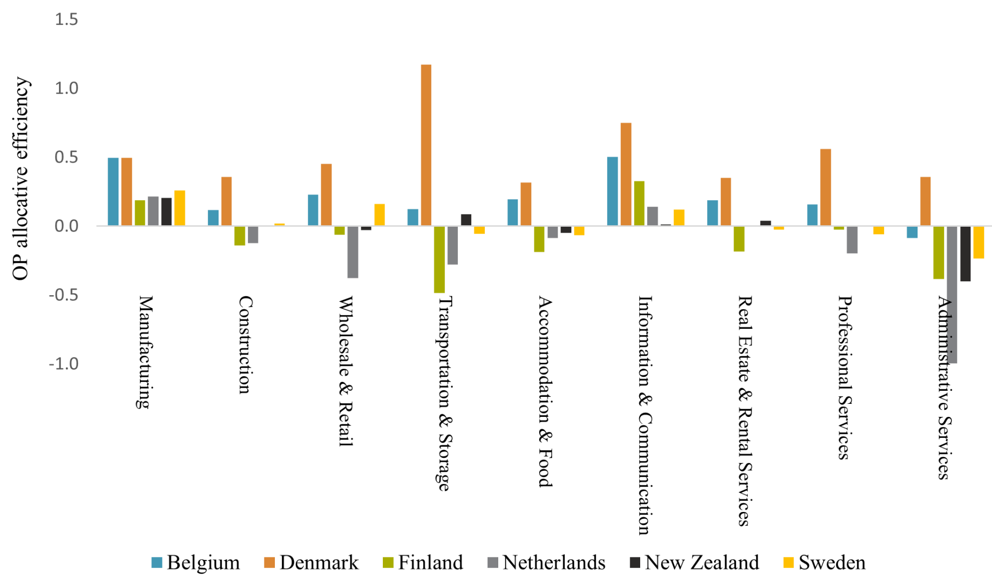
We next disaggregate the allocative efficiency results at the national level to the macro-sector level (Chart 8). Most macro-sectors in New Zealand exhibit weak positive, negative, or close to zero allocative efficiency. The administrative and support services industry appears to have the worst allocation 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

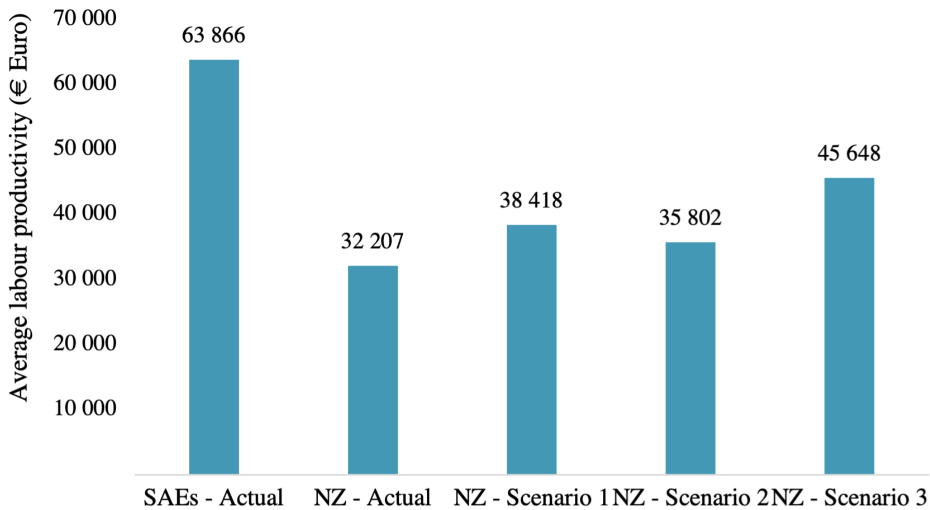
Analyses on productivity convergence and resource allocation in Sections 3 and 4 point to these factors contributing to New Zealand's poor productivity growth over the period 2003-16. We next use scenarios to quantify the possible productivity gains if improvements are made in technology diffusion and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

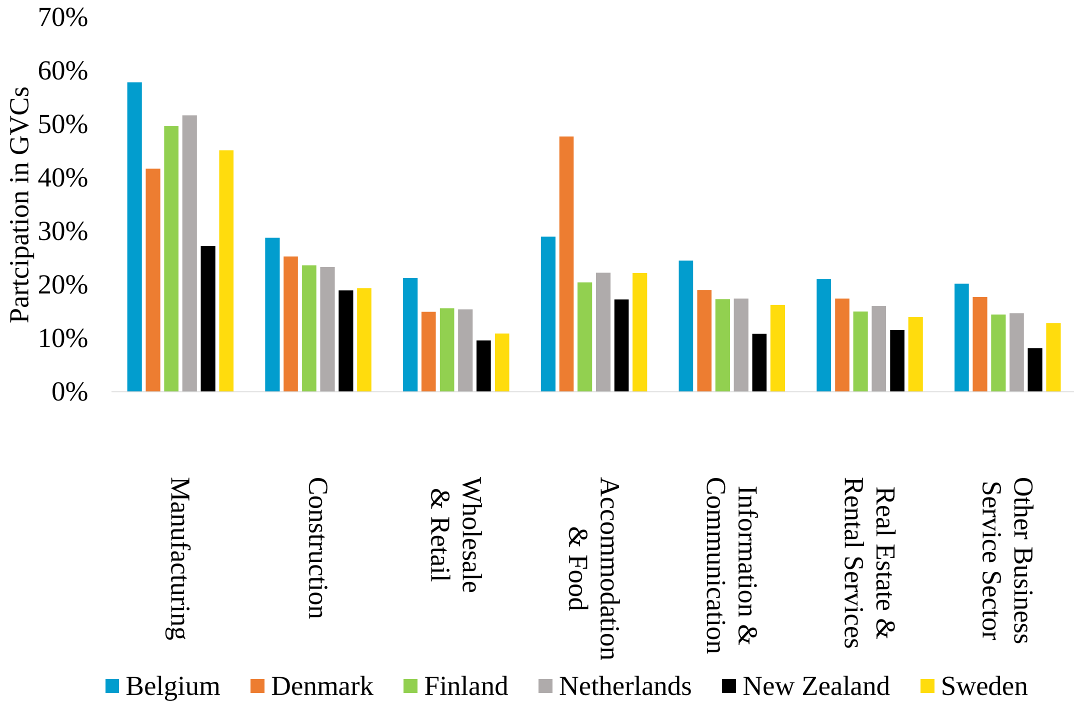
Note: Except for Belgium, all financial variables are constructed from firm-level data.

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.

The Causes of Japan's Economic Slowdown: An Analysis Based on the Japan Industrial Productivity Database

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Abstract

Using the Japan Industrial Productivity Database (JIP) and the EU KLEMS database 2017, we compare the sources of economic growth of Japan, the United States, Germany, France, and the U.K. for the period 1995–2015 using growth accounting. We find that the reasons why Japan's economic growth during the 2005–2015 period was much slower than that of the other major economies are the decline in the working-age population and sluggish investment in capital services. Among the five countries, Japan was the only one whose growth rate of the capital stock was lower than the steady state growth rate. Another reason for the slowdown in Japan's economic growth in 2005–2015 was the decline in TFP growth, which was caused by a drop in productivity growth in a small number of industries, including electronic data processing machines, electricity, and wholesale trade.

With Japan's two lost decades (Fukao, 2018a), which started from around 1990, turning into three lost decades, what the economy needs most to escape from sluggish growth is to raise productivity. Against this background, the present study

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explores productivity developments in the Japanese economy and the causes of its long-term sluggish growth, and then considers policies necessary to overcome this sluggish growth.

In order to offer the correct prescription, it is necessary to accurately understand the disease. To this end, we will focus on macro- and industry-level productivity and its determinants using the most recent version of the Japan Industrial Productivity (JIP) Database, the JIP Database 2021, by the Research Institute of Economy, Trade and Industry and Hitotsubashi University.[2] Compared with the 2015 version of the JIP Database, the JIP Database 2021 has been completely revised and, reflecting changes in the 2008 SNA, for example treats research and development (R&D) expenditure as capital formation. This makes it possible to make comparisons using recent data from the EU KLEMS database (EU KLEMS 2017 Release, Revised July 2018), which already reflects the 2008 SNA.[3] We will therefore also conduct various comparisons between Japan and other major advanced economies.

This study is organized as follows. In the first main section, using growth accounting, we examine the sources of economic growth in recent years for Japan's economy as a whole and for the manufacturing and the non-manufacturing sector. Moreover, focusing on the market economy, we compare the sources of growth for the Japanese economy with the economies of the United States, the U.K., Germany, and France. The results indicate that the United States, France, and the U.K. experienced a more serious slowdown in total factor productivity (TFP) growth in 2005–2015 vis-à-vis 1995–2005 than Japan, and that the main reason for the extremely slow growth rate of Japan's market economy compared to the other major economies during 2005–2015 was not sluggish TFP growth but the slowdown in hours worked due to demographic trends as well as a substantial slowdown in capital accumulation.

The second section therefore considers why capital accumulation in Japan has been so slow from a variety of angles, including from the perspective of neoclassical growth theory. The third section examines whether Japan's investment in information and communication technology (ICT) and intangible assets has been particularly low by comparing it with the other major economies. In the fourth section, we then use the JIP Database to examine which industries in particular were responsible for the slowdown in Japan's TFP growth in 2005–2015 compared to the preceding decade. Finally, the fifth section summarizes the findings of this study and considers what policies are necessary for Japan to emerge from its long-term eco-

2 For the international comparison, we use the JIP Database 2018 (released on March 31, 2019), which covers the period 1994-2015. In order to additionally check the most recent developments in TFP and capital accumulation, we also use the JIP Database 2021 (released on April 6, 2021). The JIP Database 2021 extends the JIP Database 2018 by adding data for the years 2016 to 2018. The JIP Database 2018 can be downloaded at https://www.rieti.go.jp/en/database/JIP2018/index.html, while the JIP Database 2021 can be downloaded at https://www.rieti.go.jp/en/database/JIP2021/index.html.

3 The EU KLEMS data can be downloaded at http://www.euklems.net/index.html.

Table 1: Sources of Japan's Economic Growth From the Supply Side, 1995-2005 and 2005-2015 (Annual Average Percent or Percentage Point Change Growth Rate)

	Market economy (excluding housing and activities not elsewhere classified)		Manufacturing		Non-manufacturing (Market ecnomy only: excluding housing and acitivites not elsewhere classified	
	1995-2005	2005-2015	1995-2005	2005-2015	1995-2005	2005-2015
Real value added	1.04	0.15	1.35	0.77	0.92	-0.09
Contribution from:						
Hours worked	-0.74	-0.59	-1.55	-0.94	-0.45	-0.48
Labour quality	0.36	0.28	0.35	0.24	0.36	0.29
Capital services	0.65	0.10	0.52	0.13	0.71	0.08
Total factor productivity	0.77	0.38	2.04	1.34	0.30	0.02

Source: JIP Database 2018 (September 2019 Revision).
Note: GDP is based on the Laspeyres chain index, while labour and capital inputs are based on the Divisia index. The growth contribution of production factors is calculated based on their rolling two-year average costs shares.
Downloaded from: https://www.rieti.go.jp/en/database/JIP2018/index.html.

nomic stagnation.

Sources of Economic Growth in Japan and Major Economies: An International Growth Accounting Comparison

Table 1 shows the growth accounting results for Japan using the JIP Database 2018. Since production-side statistics in Japan's National Accounts corresponding to the 2008 SNA are available only for 1994 onward, the JIP Database 2018 also covers only the period from 1994 onward. The following analysis therefore concentrates on the period from 1994 or 1995.

As shown by Fukao *et al.* (2007), under certain assumptions, such as constant returns to scale and perfectly competitive markets for factors of production, real gross domestic product (GDP) growth and real value-added growth in each industry can be decomposed into the contribution of labour input growth (which is equal to the sum of the contribution of increases in hours worked and the contribution of improvements in labour quality through the accumulation of education and skills), the contribution of capital services input growth, and the contribution of TFP growth, which is calculated as the residual. Table 1 presents such a decomposition for Japan's market economy (excluding housing and activities not elsewhere classified), manufacturing sector, and non-manufacturing sector (market economy only, excluding housing and activities not elsewhere classified).

The term "market economy" refers to the entirety of economic activity excluding the non-market economy (e.g., general government, education, nursing and medical care, imputed rent), where changes in product prices and real output as well as productivity growth are difficult to measure because suppliers are not compensated for their services, as in the case of government services, or services are not traded at market prices, as in the case of many medical services and imputed rent. Not only is it difficult to measure real output growth and TFP growth for the non-market economy, the way that real output is measured also differs across countries, making international comparisons difficult (for details, see Fukao *et al.*, 2017). Therefore, growth accounting for a particular country and international growth accounting comparisons are usually limited to the market economy. This applies to growth accounting studies based on the EU KLEMS database, which will be used later for international comparison,[4] as well our growth accounting for Japan, so that throughout this study we will focus on the market economy only.

Starting with the market economy as a whole, real value added growth rate (annual rate; the same applies to growth rates below) declined from 1.04 per cent in 1995–2005 to 0.15 per cent in 2005–2015.[5] During the same period, the growth rate of the economy overall including the non-market economy, i.e., GDP growth, fell from 1.11 per cent to 0.39 per cent. The fact that the growth rate of the economy overall is slightly higher than that of the market economy, and the decline in the growth rate is smaller, likely is due to the expansion of the non-market economy such as nursing care and medical care during this period.

The main reason for the slowdown in the growth of Japan's market economy in 2005–2015 vis-à-vis 1995–2005 is the slowdown in capital services input growth.

A second reason for the slowdown in economic growth is the slowdown in TFP growth. As will be discussed later, not only did TFP growth of the market economy turn negative during the period 2005–2010 (Table 3), which includes the global financial crisis, it also did not recover enough after 2010, and the TFP growth in 2005-2015 was less than that in 1995-2005.[6]

These two factors alone explain all of the 0.89 percentage point decline in the annual rate of growth of the market economy from the 1995–2005 period to the 2005–2015 period.

In addition, the contribution of labour quality improvements also declined slightly in the latter period. This reflects the fact that while many of the baby boomer generation retired during 2005–2015, many of the jobs created during the period were low-wage jobs taken up by women, whose labour force participation rose, and re-employed elderly workers (Fukao, 2018a). As we will see later, the contribution of labour quality improvements has declined substantially, especially since 2010. On the other hand, the increase in the employment rate of women and seniors counteracted the decline in hours worked due to demographic factors, i.e., the aging and shrinking of Japan's population, which as a result was less pronounced than it otherwise would have been.[7]

To examine this latter point in more de-

4 For a definition of the market economy in the EU KLEMS Productivity Accounts, see Jäger (2018). The EU KLEMS Productivity Accounts exclude the entire real estate industry, not just imputed rent, from the market economy.

5 We calculate the annual average growth rate of variable X_t for the period from 0 to T as $ln(X_T/X_0)/T$.

6 Though Japan has not suffered greatly from a housing collapse or toxic assets, its economy has been hit harder by the crisis than the United States or EU. Japan's contraction is almost entirely due to a steep fall in external demand. Fukao and Yuan (2009) use the World Input-Output Database (WIOD) to show that the fall in US demand has had an amplified effect on Japan because it not only reduces Japanese net exports to the US but also net exports of intermediate goods to Asian countries, where they would have been assembled for final export to the US.

7 Employment patterns of persons 65 and over in Japan reflect a combination of institutional factors and growing

Table 2: Rate of Change in Japan's Working-Age Population (Aged 15–64) and Total Hours Worked in the Economy Overall and the Market Economy (Average Annual Rate, per cent)

	1970-1975-	1975-1980-	1980-1985-	1985-1990-	1990-1995-	1995-2000-	2000-2005-	2005-2010-	2010-2015-	2015-2020-	2020-2025-	2025-2030-	2030-2035-	2035-2040-
Rates of change in working age population (aged 15-64)	1.16	0.79	0.90	0.86	0.26	-0.18	-0.46	-0.65	-1.12	-0.85	-0.65	-0.84	-1.14	-1.66
Rate of change in total number of workers, economy overall	0.59	0.97	0.79	1.03	0.79	-0.18	-0.35	-0.22	0.35	1.40†				
Rate of change in total hours worked, economy overall	-0.43	1.29	0.44	0.72	-0.52	-0.60	-0.69	-0.86	-0.07	0.74†				
Rate of change in total hours worked, market economy	-0.75	1.13	0.21	0.78	-0.71	-0.87	-1.35	-1.32	-0.46	0.80†				

Source: Authors' calculations. Population data for 1970–2015 are obtained from the Statistics Bureau, Ministry of Internal Affairs and Communications (https://www.stat.go.jp/english/data/jinsui/2.html).

Population estimates for 2016–2040 are the medium-fertility, medium-mortality projections by the National Institute of Population and Social Security Research (http://www.ipss.go.jp/pp-zenkoku/e/zenkoku_e2017/pp_zenkoku2017e.asp). Data for the number of workers and hours worked are obtained from the JIP Database 2015 (https://www.rieti.go.jp/en/database/JIP2015/index.html) for 1970–1995, from the JIP Database 2018 for 1995–2015, and from the JIP Database 2021 (https://www.rieti.go.jp/en/database/JIP2021/index.html) for 2015–2018.

Note: Figures denoted with † are for 2015–2018.

tail, Table 2 presents the pace of decline in Japan's working-age population (those aged 15–64 years old),[8] changes in the total number of workers, and changes in total hours worked in the economy overall and in the market economy.

As can be seen in Table 2, total hours worked fell sharply from 1990 onward. This drop was mainly caused by the decline in the working-age population as well as the decline in the average hours worked per worker. The decline in the working-age population reflects Japan's low birthrate and population aging and was particularly large in the 2010s due to the retirement of the baby boomers. The decline is expected to continue in the coming decades.

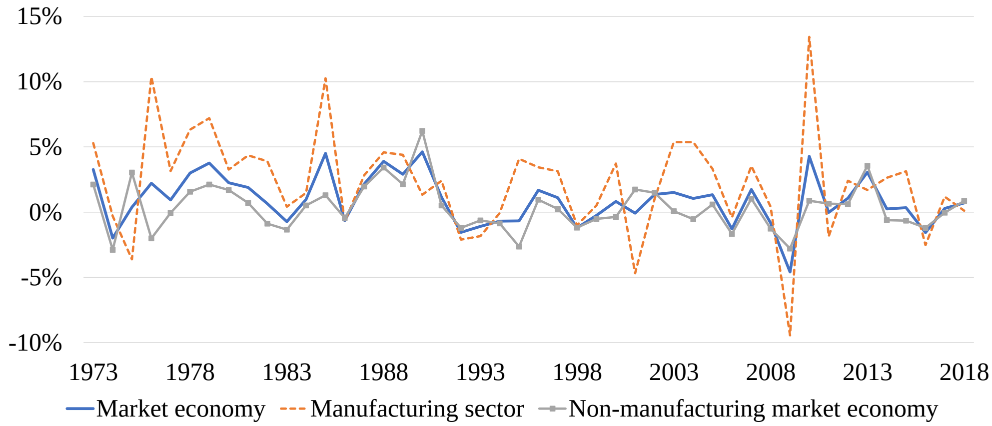
At the same time, the shrinking of the working age population has been partly offset by the growing labour participation of women and seniors, so that since 1985 the growth in the total number of workers has tended to be higher than that of the working age population.

Regarding the decline in hours worked per worker, two factors can be pointed out. The first, as highlighted by Hayashi and Prescott (2002), is the amendment of Japan's Labour Standards Act in 1987, introducing the 40-hour, five-day workweek. Hours worked gradually declined until the full implementation of the amendment in

life expectancy. Many major corporations and organization have a mandatory retirement age, which is often younger than the pensionable age, forcing many elderly workers to find work after reaching the mandatory retirement age. At the same time, due to rising life expectancy and growing fiscal pressure, the government has been gradually raising the pensionable age and is providing incentives for seniors to delay claiming their pension until age 70. These factors have led to an increase in part-time employment among seniors in recent years.

8 Figures from 2016 onward are based on the population projections of the National Institute of Population and Social Security Research.

Chart 1: Total Factor Prodcutivity Growth in Japan, 1973–2018 (per cent)



Source: Authors' calculations based on the JIP Database 2015 (1993 SNA) for 1973–1994 and the JIP Database 2021 (2008 SNA) for 1995–2018.
Note: The value for 1973 is the annual average growth rate of TFP in from 1970 to 1973.

1997. The second factor is the increase in part-time workers, which explains why average hours worked continued to decline even after the full implementation of the 40-hour week.

Returning to Table 1 and looking at the growth accounting results where the market economy is divided into the manufacturing and the non-manufacturing components, the main reasons for the slowdown in growth in 2005-2015 were the deceleration in capital services input growth and TFP growth. In the manufacturing sector, the negative growth contribution of the decline in hours worked became smaller in the 2005–2015 period. This is likely the result of the recovery of the manufacturing sector due to the depreciation of the yen (Fukao and Nishioka, 2021).

In summary, the results of the growth accounting analysis for Japan indicate that the main causes of the slowdown in economic growth from the 1995–2005 period to the 2005–2015 period were sluggish capital accumulation and the decline in TFP growth.

Many earlier studies, such as Hayashi and Prescott (2002), Fukao (2013), and Jorgenson, Nomura, and Samuels (2016), have pointed out that the slowdown in Japan's TFP growth occurred after the burst of the "bubble economy" in 1989–1990 and that the continued slow growth of TFP seems to be one of main proximate causes of Japan's lost decades from the 1990s. To examine whether Japan's TFP growth has improved in recent years, we plot the annual TFP growth rate of the market economy, the manufacturing sector, and the non-manufacturing market economy in Chart 1. The annual TFP growth rates for 1973–1994 are obtained from the JIP Database 2015, which is based on the 1993 SNA, while the growth rates for 1995–2018 are obtained from the JIP Database 2021, which is based on the 2008 SNA.[9]

Since the stagnation of capital deepening is the main cause of Japan's slow economic growth in recent years, we also plot annual

9 In Chart 1, the TFP growth rate for a certain year (for example, 2018) refers to the growth rate from the previous year (2017) to that year (2018).

data of the ratio of nominal gross capital formation to the nominal capital stock (referred to as the investment-capital stock ratio hereafter) in Chart 2. The chart depicts this ratio for total capital, ICT capital, and non-ICT capital. Data for 1970–1993 are based on the JIP Database 2015 (1993 SNA), in which non-ICT capital does not include R&D stock, and data for 1994–2018 are based on the JIP Database 2021 (2008 SNA), in which non-ICT capital includes R&D stock.[10]

Chart 1 shows that there was a sharp drop in TFP growth around 1990. Annual average TFP growth of the market economy declined from 1.8 per cent in 1973–1990 to 0.3 per cent in 1990–2018.[11] The decline occurred both in the manufacturing sector (from 3.5 per cent in 1973–1990 to 1.3 per cent in 1990–2018) and the non-manufacturing market economy (from 1.0 per cent in 1973–1990 to -0.1 per cent in 1990–2018).

During the three lost decades, 1990–2018, there were substantial changes in TFP growth. The 1990s were characterized by large macroeconomic shocks, such as the burst of "bubble economy" (1990–1993), the Asian financial crisis (1997–1998), and Japan's domestic financial crisis (also 1997–1998), which probably are a major reason for the sluggish TFP growth. Specifically, in 1990–2000, the annual average rate of TFP growth in the market economy overall was -0.1 per cent, that in the manufacturing sector 1.2 per cent, and that in the non-manufacturing market economy -0.6 per cent. The fact that the non-manufacturing market economy performed much worse during this decade than the manufacturing sector likely reflects that small and medium-sized enterprises (SMEs), which are more vulnerable to financial distress, make up a larger share, and more firms had invested in real estate, so that the non-manufacturing market economy was hit more seriously by the burst of the "bubble economy" and the Asian and Japanese financial crises.

By 2000, Japan had more or less resolved the non-performing loan problem in its banking sector and firms had repaired their damaged balance sheets. As a result, TFP growth in 2000–2007 recovered to 0.8 per cent in the market economy overall, 1.9 per cent in the manufacturing sector, and 0.4 per cent in the non-manufacturing market economy. However, even during this relatively stable period, Japan's TFP growth was much lower than before 1990.[12]

Since the 1990s, certain core character-

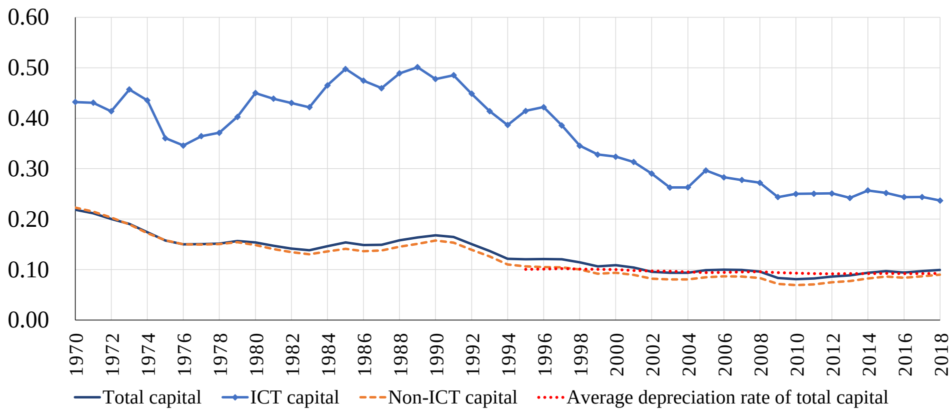
10 The definition of ICT capital goods in the JIP Database 2015 is broader than in the JIP Database 2021. For example, non-digital copiers and non-digital cameras are included in ICT capital goods in the 2015 version but not in 2021 version. On the other hand, in-house software investment is not included in ICT capital formation in the 2015 version but is included in the 2021 version.

11 The annual average TFP growth rate in 1973–1990 refers to the TFP growth from 1973 to 1990, which is calculated as the average of the annual TFP growth rates for 1974 to 1990. Growth rates for all other periods were calculated in a similar manner.

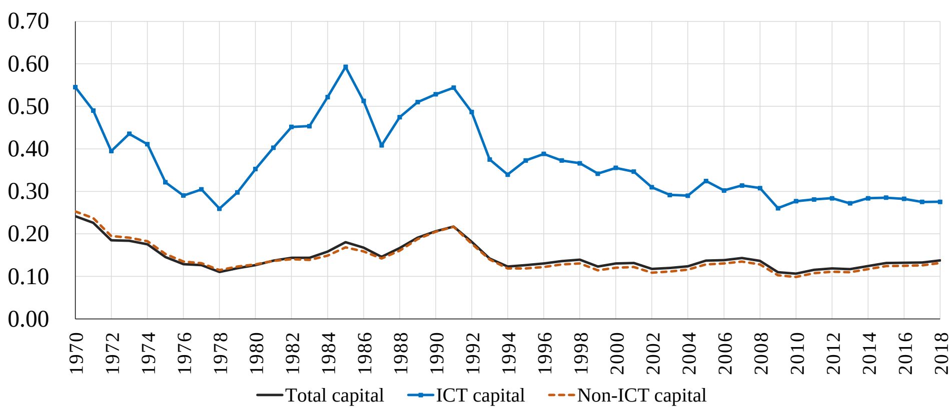
12 In addition to low TFP growth, Japan also suffers from another structural problem: insufficient demand (sometimes also referred to as the "excess saving problem"). For more on the problem of insufficient demand, see Fukao *et al.* (2016) and Fukao and Settsu (forthcoming). We should also note that low TFP growth might be in part caused by insufficient demand.

Chart 2: Nominal Gross Capital Formation/Nominal Capital Stock: 1970–2018

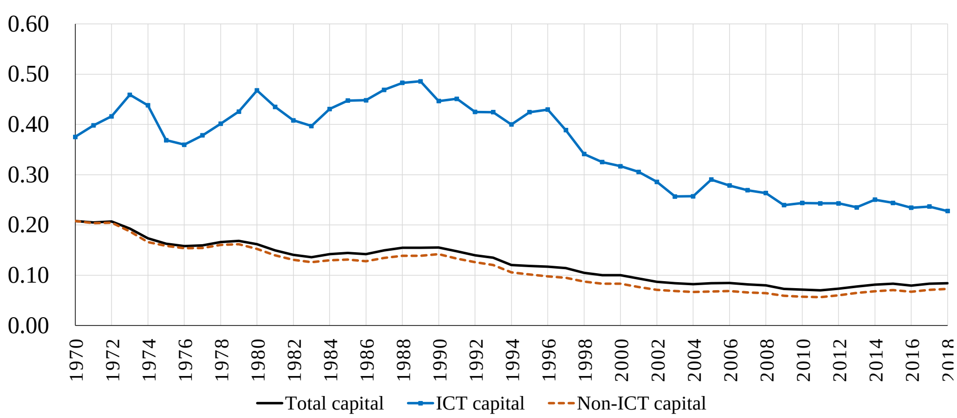
Panel A: Market Economy



Panel B: Manufacturing Sector



Panel C: Non-manufacturing Market Economy



Source: Authors' calculations based on the capital formation matrix of the JIP Database 2015 for 1970–1993 and the JIP Database 2021 for 1994–2018. Non-ICT capital data for 1994–2018 include the R&D stock.

istics of Japanese firms, such as close customer–supplier relationships and the lifetime employment system, have become obstacles to TFP growth in an environment shaped by globalization and slow/negative growth in the working age population. The reasons are as follows.[13]

First, from the 1990s, firms have increased the number of part-time workers in order to maintain the flexibility of employment levels. Given the decline of the working age population and economic stagnation, most firms cannot expect their need for employees to steadily increase, as was the case during the high-speed growth era (1955–1970). At the same time, areas in which individual firms have a competitive advantage over their rivals have been changing quickly and Japan's comparative advantage as a whole has also been evolving over time. Given the high job security provided under traditional employment practices, increasing the reliance on part-time workers has been almost the only way for firms to keep both the level and the mix of employment flexible.

Second, the structural causes of Japan's lackluster economic growth, such as the slow economic metabolism (entry and exit of firms),[14] sluggish investment in information and communication technology (ICT) at SMEs and the ineffective use of ICT, as well as insufficient investment in intangibles (training, new methods, brands) are closely related with labour issues. An example of the ineffective use of ICT is that firms often choose to purchase custom software rather than packaged software in order to avoid changes in corporate structure, employment adjustment, and training of workers. And since ICT engineers prefer to work for large firms due to the greater job security,[15] SMEs face difficulties in hiring such workers (Fukao *et al.* 2016). Meanwhile, many firms do not or cannot expand their reliance on outsourcing of ICT services because they are reluctant to adjust their employment levels (e.g., through layoffs).

Third, close customer–supplier relationships have weakened, and this change resulted in SMEs being left behind in terms of new technologies and internationalization. Since the mid-1990s, large Japanese firms, especially in the manufacturing sector, have been restructuring their business. As part of these restructuring measures, firms only partly filled positions left by retiring workers, replaced full-time workers with part-time workers, streamlined buyer-supplier relationships by making them more flexible and international, and relocated production abroad (Paprzycki and Fukao, 2008, Fukao *et al.* 2016, Fukao 2018a). It appears that these measures, such as the closure of factories in Japan by large R&D intensive firms and looser relationships with suppliers have

13 For more details about these issues, see Fukao (2012, 2018a), Fukao *et al.* (2016), and Fukao and Settsu (forthcoming).

14 On this issue, see Baily, Bosworth, and Doshi (2020).

15 Since the secondary labour market (i.e., for those who are not new graduates) is narrow and jobs of regular employees (seishain) at large firms are more secure than those at SMEs, new graduates in Japan have a strong incentive to obtain a job as a regular employee at a large firm.

reduced technology spillovers from large firms to SMEs (Belderbos *et al.*, 2013, Ikeuchi *et al.* 2015). These restructuring efforts of large firms continued in the 2000s, boosting their TFP growth. On the other hand, SMEs were left behind (Fukao, 2012, 2013, 2018a), resulting in much lower TFP growth that reflects lackluster R&D and a low degree of internationalization.

Next, the period 2007–2011 was again characterized by a deterioration in TFP growth, reflecting the global financial crisis of 2008–2009 and the Tohoku earthquake of March 2011. The TFP growth rate for the market economy overall was -0.3 per cent, that in the manufacturing sector 0.6 per cent, and that in the non-manufacturing market economy -0.6 per cent. TFP growth subsequently recovered in 2011–2018, registering 0.6 per cent in the market economy overall, 1.2 per cent in the manufacturing sector, and 0.4 per cent in the non-manufacturing market economy.

Chart 2 shows that the investment-capital stock ratio also declined after 1990. However, this decline occurred gradually, unlike the sharp drop in TFP after 1990.[16] Several reasons why the decline was gradual can be noted. First, the Bank of Japan adopted an accommodative monetary policy stance and gradually began to employ unconventional monetary policies. However, because of the zero lower bound on nominal interest rates, the effectiveness of additional monetary easing appears to have decreased over time. The Japanese government also sought to stimulate private investment through various policies such as investment tax credits and the provision of credit guarantees for SMEs. Second, as seen in Table 2, the working age population continued to decline during this period. This trend shifted downward the steady state growth rate of the economy and the steady state level of the investment-GDP ratio over time. Third, it appears that during the period from 1990 to the mid-2000s Japanese firms gradually realized that the long-run growth rate of the economy had substantially shifted downward and adjusted their investment accordingly.

Due to these factors, the period from 1990 to the mid-2000s can be regarded as a transition period from an ordinary developed economy with modest economic growth to an economy suffering from severe stagnation with a shrinking labour force, stagnant TFP, and very limited capital accumulation.

When the investment-capital ratio is lower than the depreciation rate, the real capital stock will decrease.[17]According to the JIP Database 2021, the average capital depreciation rate in the market economy during 2005–2018 was 29.6 per cent for ICT capital, 7.9 per cent for non-ICT capi-

16 According to the JIP Database 2021, the capital-labor ratio also gradually declined. Specifically, the annual average growth rate of the capital stock-labor input ratio in the market economy fell from 1.70 per cent in 1994-2000 to 1.23 per cent in 2000-2005, 0.77 per cent in 2005-2010, 0.15 per cent in 2010-2015, and 0.06 per cent in 2015-2018. The annual average growth rate of the capital service input-labor input ratio in the market economy in the corresponding periods was 2.86 per cent, 1.51 per cent, 1.28 per cent, 0.18 per cent, 0.19 per cent respectively.

17 Let $K_{i,j}$, $\Delta K_{i,j}$, $I_{i,j}$, p_j, δ_j, and Ω denote the real stock of capital good j in sector i, changes in $K_{i,j}$, real gross capital formation with respect to capital good j in sector i, the price of capital good j, the depreciation

tal, and 9.3 per cent for capital goods overall.[18] Chart 2 shows that the investment-capital stock ratio of both ICT capital and non-ICT capital gradually declined after 1990 and approached the depreciation rate in both the manufacturing sector and the non-manufacturing market economy by the mid-2000s. This means that since the mid-2000s the real capital stock in Japan's market economy has almost stopped growing.[19] As a result, the 2005–2015 period as a whole was a period of extremely sluggish capital accumulation.

We should also note that this sluggish capital accumulation may have affected TFP growth. For instance, slow capital accumulation raises the average age of the capital stock and delays the introduction of new technologies, thus reducing TFP growth. Compared with 1990, the average age of equipment in 2017 had increased by 91.8 per cent at SMEs and 48.0 per cent at large firms (Small and Medium Enterprises Agency, 2019, Figure 1-1-12). On the other hand, since TFP growth is calculated as the residual, slower capital accumulation may have resulted in higher observed TFP growth.

Having looked at the source of growth in Japan in some detail, let us now compare developments in Japan with those in the United States, Germany, France, and the U.K. The results are presented in Table 3. For the United States, Germany, France, and the U.K., we use data from EU KLEMS 2017. Like the JIP Database 2018, which we use for the international comparison, EU KLEMS 2017 is based on the 2008 SNA and therefore can be said to be compiled based on almost identical standards.

The first interesting fact that emerges from this table is that since 2005 TFP growth has been sluggish not only in Japan but also in most of the other countries included in the comparison. As already mentioned, Japan's TFP growth declined in the 2005–2015 period relative to 1995—2005; however, what our results show is that, apart from Germany, TFP growth has fallen to an even greater extent in the other countries. As a result, Japan, which had the second lowest TFP growth rate (after Germany) in the 1995–2005 period, had the second highest TFP growth rate (again after Germany) in the 2005–2015 period. On the other hand, TFP growth fell substantially in the United States, France, and the U.K. during the 2005–2015 period relative

rate of capital good *j*, and the set of the capital goods. The growth rate of the real capital stock (Laspeyres index) in sector *j* can then be expressed by:

$$\frac{\sum_{j\in\Omega} p_j \Delta K_{i,j}}{\sum_{j\in\Omega} p_j K_{i,j}} = \frac{\sum_{j\in\Omega} p_j I_{i,j}}{\sum_{j\in\Omega} p_j K_{i,j}} - \frac{\sum_{j\in\Omega} p_j \delta_j K_{i,j}}{\sum_{j\in\Omega} p_j K_{i,j}}$$

The first term on the right-hand side denotes the nominal gross capital formation-nominal capital stock ratio in sector *i*, while the second term denotes the average capital depreciation rate in sector *i*.

18 These depreciation rates are based on the results of surveys on capital depreciation rates by the Cabinet Office.

19 We should note that capital depreciation rates differ slightly across sectors. Since R&D stock, which depreciates quickly, makes up a large share of the total non-ICT capital in the manufacturing sector, the average capital depreciation rate for non-ICT capital in this sector is higher than in the market economy. Similarly, since structures, which depreciate slowly, make up a large share of the total non-ICT capital in the non-manufacturing sector, the average capital depreciation rate for non-ICT capital in this sector is lower than in the market economy.

Table 3: Sources of Growth in the Market Economy From The Supply-Side: Japan, United States, Germany, France, U.K. Comparison (Average Annual Rate of Change)

	1995-2000	2000-2005	2005-2010	2010-2015	**1995-2005**	**2005-2015**
Japan						
Real value added	1.19	0.89	-0.51	0.82	1.04	0.15
Contribution of:						
Hours worked	-0.58	-0.90	-0.88	-0.31	-0.74	-0.59
Labour quality	0.34	0.37	0.33	0.22	0.36	0.28
Capital services	0.92	0.39	0.17	0.02	0.65	0.10
Total factor productivity	0.51	1.03	-0.13	0.89	0.77	0.38
United States						
	1995-2000	2000-2005	2005-2010	2010-2015	**1995-2005**	**2005-2015**
Real value added	4.29	2.06	-0.07	1.79	2.70	0.86
Contribution of:						
Hours worked	0.69	-0.52	-1.00	0.87	-0.18	-0.07
Labour quality	0.13	0.24	0.24	0.13	0.21	0.18
Capital services	1.94	1.00	0.53	0.71	1.26	0.62
Total factor productivity	1.54	1.36	0.17	0.08	1.41	0.12
Germany						
	1995-2000	2000-2005	2005-2010	2010-2015	**1995-2005**	**2005-2015**
Real value added	1.89	0.52	1.11	1.79	1.20	1.45
Contribution of:						
Hours worked	-0.21	-0.84	0.17	0.45	-0.53	0.31
Labour quality	-0.09	0.32	-0.06	0.16	0.12	0.05
Capital services	1.54	0.74	0.78	0.33	1.14	0.56
Total factor productivity	0.65	0.30	0.21	0.85	0.48	0.53
France						
	1995-2000	2000-2005	2005-2010	2010-2015	**1995-2005**	**2005-2015**
Real value added	3.77	1.74	0.66	1.02	2.75	0.84
Contribution of:						
Hours worked	0.88	0.17	0.23	0.13	0.52	0.18
Labour quality	0.30	0.38	0.28	0.62	0.34	0.45
Capital services	1.04	1.05	0.66	0.40	1.05	0.53
Total factor productivity	1.54	0.15	-0.50	-0.13	0.84	-0.31
U.K.						
	1995-2000	2000-2005	2005-2010	2010-2015	**1995-2005**	**2005-2015**
Real value added	3.86	2.62	0.11	2.17	3.09	1.14
Contribution of:						
Hours worked	0.65	-0.12	-0.57	1.27	0.17	0.35
Labour quality	0.29	0.45	0.37	0.33	0.39	0.35
Capital services	1.46	0.90	0.24	0.55	1.11	0.40
Total factor productivity	4.46	1.39	0.06	0.02	1.42	0.04

Source: Authors' calculations based on the JIP Database 2018 (September 2019 Revision) for Japan and EU KLEMS 2017 (Revised July 2018) for the other countries. The EU KLEMS data were downloaded from http://www.euklems.net/index.html.

Note: To calculate the growth contribution of each production factor, factor cost shares are used for Japan, while for the other countries the ex post income shares are used. Due to data limitations in the EU KLEMS data, our growth accounting for the United States and the U.K. starts from 1998 and 1997, respectively.

to 1995-2005. The growth accounting for five-year intervals suggests that not only did TFP growth in these countries fall during 2005–2010, likely reflecting the global financial crisis, it also failed to improve during 2010–2015, which includes the recovery from the global financial crisis. As pointed out by Gordon (2012), Summers (2013), and others, there may have been a global slowdown in technological innovation, particularly in the United States, which might explain this decline in TFP growth. Another possible explanation of the low TFP growth in these countries is that after the global financial crisis these countries introduced unconventional monetary policies, which may have led to excess capital formation, reducing TFP growth in a similar manner as in Japan in the 1990s.

Although Japan's TFP growth rate during 2005–2015 was much lower than in the preceding decade, it was still higher than that for the United States, France, and the U.K. Nevertheless, the growth rate of Japan's market economy remained the lowest of the five countries. In addition to the decline in hours worked due to demographic factors, the reason for this is that the contribution of capital services input growth was remarkably low.

Therefore, to improve Japan's growth prospects, it will be necessary to tackle the other two sources of Japan's economic slowdown, namely, the slowdown in capital accumulation and TFP growth. It is unlikely that much can be done to substantially mitigate the decline in the number of hours worked brought about by the shrinking of Japan's working-age population shown in Table 2. For example, the working-age population is expected to decrease by 5.3 million between 2020 and 2030. It will be difficult to offset this decline simply by accepting more foreign workers or by further increasing the employment rate of women and persons 65 and over.[20]

The Slowdown in Capital Accumulation in Japan

Let us consider the slowdown in capital accumulation in Japan. When a country's economic growth heavily relies on capital accumulation, the diminishing marginal returns to capital will cause the rate of return on capital to fall, which in turn will reduce capital accumulation and slow economic growth. However, if labour input increases, or if technological progress has the same effect as an increase in labour input, the diminishing marginal returns to capital will be counteracted and a high rate of capital accumulation may be maintained. We therefore examine whether the slowdown in capital accumulation in Japan in recent years is sufficiently severe to be explained by the shrinking of Japan's population and low TFP growth.

Let us examine this question from the perspective of neoclassical growth theory. According to standard neoclassical growth theory, in an advanced economy that has accumulated sufficient capi-

20 The social costs associated with accepting sufficiently large numbers of unskilled workers from developing countries would be very high. Even in the case of skilled workers, since Japan has a relatively ethnically homogeneous population with a limited tradition of significant immigration, Japan would need substantial reforms of its education system, public consciousness, etc., in order to accept large numbers of immigrants without substantial social costs.

tal, assuming that technological progress is Harrod-neutral, under steady-state growth in which the marginal productivity of capital does not diminish (balanced growth), the rate of capital accumulation is equal to the rate of GDP growth (natural growth rate), which is defined as the sum of the rate of labour input growth and the Harrod-neutral rate of technological progress (Acemoglu, 2009, Chapter 2). According to neoclassical growth theory, if the rate of capital accumulation exceeds the natural growth rate, the rate of return on capital declines due to diminishing marginal returns, so that the rate of capital accumulation declines. When the rate of capital accumulation falls below the natural growth rate, capital becomes scarce, the rate of return on capital rises, and the rate of capital accumulation rises. Thus, there is a mechanism based on which the economy returns to a balanced growth path once it deviates from it.

Based on this neoclassical growth theory perspective, we calculate the natural growth rate (and the rate of capital accumulation in balanced growth, which equals the natural growth rate) for the five countries (Japan, United States, Germany, France, and U.K.) and compare it with the actual rate of increase in the capital stock. As in Tables 1 and 3, we exclude the non-market economy, for which TFP is difficult to measure, and examine TFP, labour input, and capital accumulation for the market economy only.

Assuming Harrod-neutral technological progress, the rate of technological progress equals the TFP growth rate divided by the income share of labour.[21] The natural growth rate in Table 4 (which in balanced growth is equal to the rate of increase in the capital stock) is calculated as the sum of the rate of Harrod-neutral technological progress calculated as described and the rate of change in labour input. The labour input growth rate in the table is the sum of changes in hours worked and labour quality improvements.

In Table 4, in row (e) for each country, the growth rate of the capital stock on a balanced growth path (which is equal to the natural growth rate) is calculated from the actual growth rate of labour input and TFP. According to this table, Japan's natural growth rate (for the market economy) was the lowest among the five countries, at 0.11 per cent per year during 2005–2015. Germany had the highest natural growth rate, followed by the U.K., France, and the United States. While Japan, as mentioned earlier, had the second highest TFP growth rate after Germany during this period of slowing TFP growth worldwide, Japan's natural growth rate was much lower than that of the other

21 As mentioned earlier, the growth accounting analysis for Japan uses information on cost shares rather than income shares. However, in the calculations in Table 4, for the comparison with the other countries, the labour income share is used for calculating Harrod-neutral technological progress. Since the cost share of labour in Japan, at 0.67 in 1995–2005 and 0.68 in 2005–2015, was higher than the income share (i.e., on average, firms' operating surplus was higher than their cost of capital), using cost shares results in a rate of Harrod-neutral technological progress for Japan that is lower than that shown in Table 4, and its natural growth rate is lower than in Table 4. If income shares are used in the growth accounting analysis for Japan in Tables 1 and 3, as in the EU KLEMS database, the TFP growth rate calculated as the residual will be somewhat smaller since the negative contribution of changes in labour input to growth will be smaller.

Table 4: Natural Growth Rate and Capital Growth Rate for the Market Economy: Japan, United States, Germany, France, and U.K. 1995-2005 and 2005-2015 (Average Annual Per Cent Change)

		Japan		United States		Germany		France		U.K.	
		1995-2005-	2005-2015-	1998-2005-	2005-2015-	1995-2005-	2005-2015-	1995-2005-	2005-2015-	1997-2005-	2005-2015-
Labour input growth	a	-0.69	-0.58	0.05	0.18	-0.57	0.52	1.22	0.86	0.81	0.99
TFP growth	b	0.77	0.38	1.41	0.12	0.48	0.53	0.84	-0.31	1.42	0.04
Labor income share (%)	c	55.40	54.87	63.45	60.00	71.38	68.61	70.63	73.41	68.92	70.85
Harrod-neutral technological progress	$d = b/c$	1.39	0.69	2.22	0.20	0.67	0.77	1.19	-0.42	2.06	0.06
Natural growth rate = Growth rate of capital stock on balanced growth path	$e = a + d$	0.70	0.11	2.27	0.38	0.10	1.30	2.41	0.44	2.87	1.04
Actual capital stock growth rate	f	1.34	0.01	5.32	2.36	3.10	1.80	3.10	1.80	5.17	1.92
Actual capital stock growth rate minus growth rate on balanced growth path	$g = f - e$	0.64	-0.09	3.05	1.98	3.00	0.51	0.69	1.37	2.30	0.88

Source: See Table 3. Data for the market economy are used.

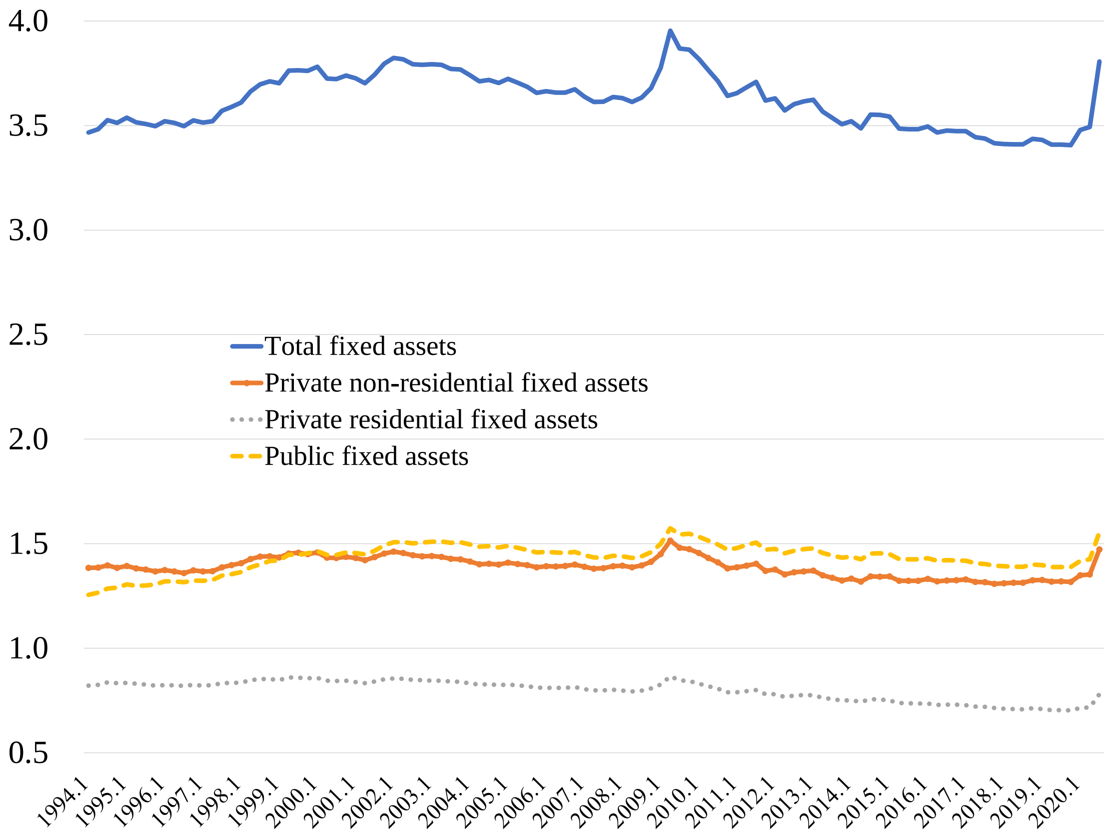
countries due to the decline in labour input reflecting demographic trends.

Next, we compare the actual capital stock growth rate (row (f)) with the natural growth rate of each country's market economy calculated as described above (row ((e)). Looking at the period 2005–2015, we find that unlike in other countries, where the capital stock growth rate was around 2 per cent, in Japan the actual capital stock growth rate during that period was only 0.01 per cent and thus below the natural growth rate, which itself was already lower than in the other countries.

While further research is needed to understand why Japan's capital accumulation between 2005 and 2015 was so much lower than in other major economies, possible reasons include the following: (1) While other major industrialized countries embarked on large-scale monetary easing after the global financial crisis to stimulate capital accumulation, in Japan there was little room to stimulate capital accumulation through further monetary easing, since the Bank of Japan had already been pursuing monetary easing for many years to bring the economy out of its long-term stagnation. (2) Until 2012, when Abenomics was launched,[22] the yen continued to appreciate against the United States dollar and other currencies reflecting monetary easing in other major economies, hurting the manufacturing sector. (3) Having transferred production overseas, large firms have tended to use their corporate savings to increase their investment and lending overseas rather than investing them at home; in addition, in recent years, they have also increasingly tended to spend profits on dividend payouts rather than investment (Fukao *et al.*, 2019).

22 Initially, Abenomics (2013–2020) consisted of three arrows: aggressive monetary policy, active fiscal policy, and a growth strategy (including measures to improve productivity).

Chart 3: Developments in the Real Capital Stock-GDP Ratio for Japan: 1994Q1–2020Q3, Total Economy



Source: The denominator for each variable is quarterly real GDP (seasonally adjusted, 2015 benchmark year) from the "Quarterly Estimates of GDP for Jul.-Sep. 2020 (The Second Preliminary Estimates)," Cabinet Office, Government of Japan. The numerators are the quarterly fixed capital stock series from the "Quarterly Estimates of Net Capital Stocks of Fixed Assets, Jul.-Sep. 2020" (2015 benchmark year; 2008 SNA), Cabinet Office, Government of Japan. The data were downloaded from: https://www.esri.cao.go.jp/en/sna/menu.html.

Against this background, let us examine developments in capital accumulation in Japan, including more recent years not covered in the JIP Database 2021, which only goes up to 2018. We therefore use data from the Cabinet Office to show developments in the ratio of the real fixed capital stock of various types of capital to real GDP (both denominator and numerator in 2015 prices) in Chart 3.

Chart 3 indicates that the real capital stock-output ratio for total fixed assets rose considerably from 1994, the first year for which data are available, to the early 2000s. However, since then it has been on a rapidly declining trend, with the exceptions of a spike around 2009, when real GDP fell precipitously due to the collapse in exports triggered by the global financial crisis, and another spike after the second quarter of 2020, when real GDP fell due to the outbreak of COVID-19. Breaking down total fixed assets into private non-residential fixed assets (including intellectual property products accumulated through research and development, etc.), public fixed assets, and private residential fixed assets, we find that whereas the ratios of public fixed assets and private residential fixed assets to GDP have continued to fall, the ratio of private non-residential fixed assets, which corresponds to the capital stock of the market economy, to GDP stopped falling in 2015. As mentioned in passing earlier, the share of the market economy in GDP has been declining due to the expansion of non-market sectors such as health care and nursing care. It seems that the capital stock of private non-residential fixed assets divided by the gross value added of the market economy excluding housing stopped declining from the mid-2010s until the outbreak of COVID-19.

Next, let us examine why the capital-GDP ratio stopped increasing and started to decline around 2002–2003. As already discussed in the previous section, one explanation is that because of the drop in TFP growth after 1990, the gradual decline in the working age population, the persistent insufficient demand, and the zero interest rate constraint on monetary easing, the period from 1990 to the mid-2000s was a transition period from an economy with modest economic growth to one characterized by severe stagnation with very limited capital accumulation. In order to investigate the stagnation of capital accumulation in more detail, Chart 4 shows how the return on capital, the rental price of capital, and the capital-output ratio changed in the market economy, the manufacturing sector, and the non-manufacturing market economy during the period 1995–2018. Specifically, Chart 4 shows the annual data of the following four variables:

- Gross operating surplus/Nominal capital stock = (Nominal gross value added at factor costs − labour cost)/Nominal capital stock
- Rental price of capital = Capital cost/Nominal capital stock = Long-term interest rate + Capital depreciation rate − Capital gains[23]
- Excess return on capital = Gross operating surplus/Nominal capital stock - Rental price of capital
- Capital-output ratio = Real capital stock/Real value added (in 2011 prices)

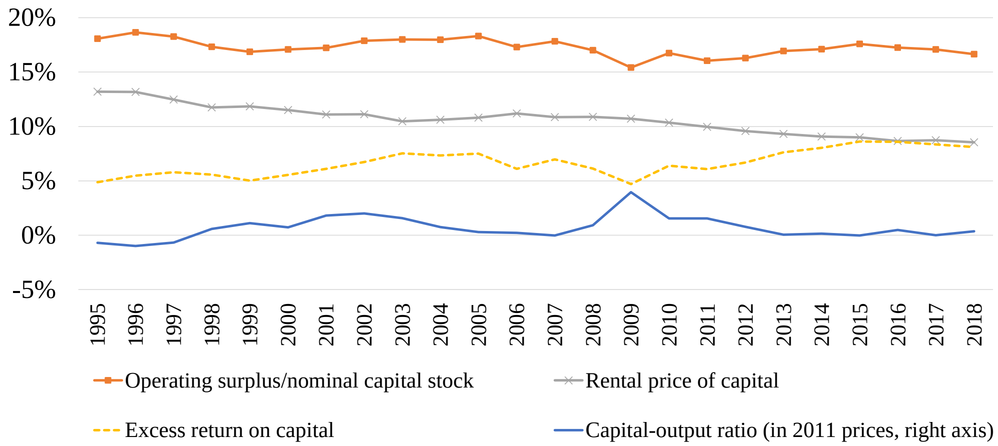
When the excess return on capital increases, firms will invest more and the capital-output ratio will increase. As already discussed in the previous section, the Bank of Japan increased monetary easing in the 1990 and early 2000s and succeeded in reducing the rental price of capital. While the ratio of the gross operating surplus to the nominal capital stock did not recover during the period 1995–2003, the decline in the rental price of capital raised the excess return on capital, mainly in the non-manufacturing market economy. This, in turn, appears to have contributed to the slowdown in the decline in the ratio of nominal gross capital formation to the nominal capital stock, but the decline in the rental price of capital was not sufficient to stop the decline or lead to an increase in the ratio of nominal gross capital formation to the nominal capital stock (Chart 2).

In 2006, the Bank of Japan terminated its quantitative-easy policy and zero-interest policy as the decline in the Consumer Price Index came to a halt, market interest rates started to increase, and

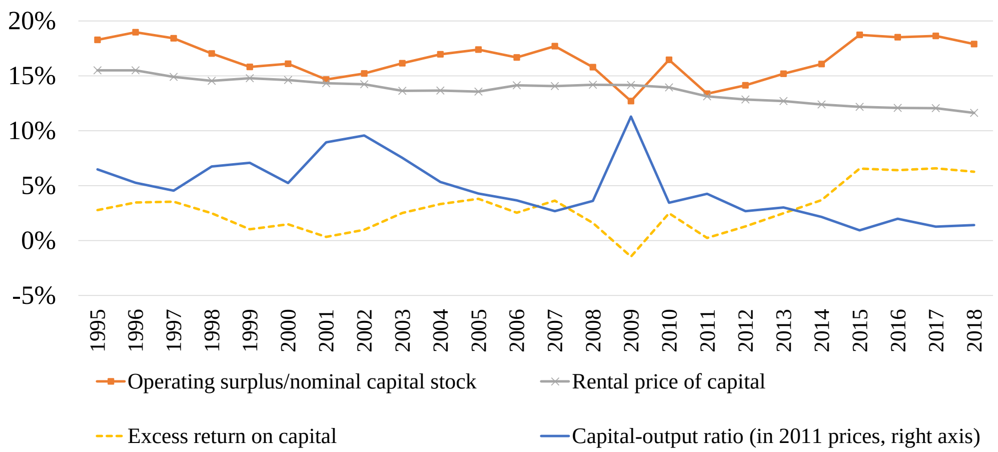
23 The cost of capital is adjusted for tax saving effects.

Chart 4: Excess Return on Capital and Capital-Output Ratio in Japan, 1995-2015

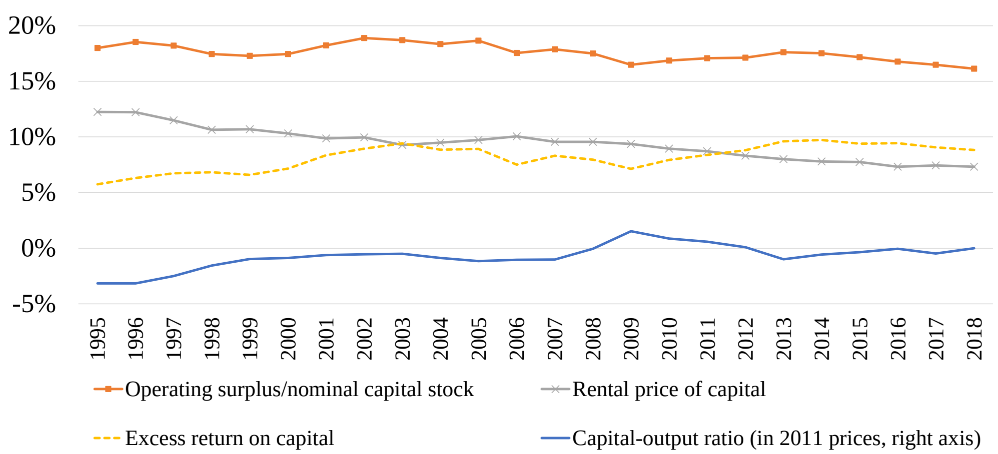
Panel A: Market Economy



Panel B: Manufacturing Sector



Panel C: Non-manufacturing Market Economy



Source: Authors' calculations based on the JIP Database 2021.

the decline in the rental price of capital also came to an end. The global financial crisis of 2008–2009 reduced the operating surplus-capital stock ratio and further reduced the excess return on capital.

From 2013, the Bank of Japan once again stepped up its unconventional monetary easing and increased investment in risk assets such as index-linked exchange-traded funds and Japan Real Estate Investment Trusts. This policy led to a substantial depreciation of the yen (Fukao and Nishioka 2021).[24] However, although the excess return increased substantially (Chart 4) under Abenomics, it did not lead to an increase in the ratio of nominal gross capital formation divided by the nominal capital stock (Chart 2).

Another potential explanation of Japan's slow capital accumulation is substitution between capital and labour. As already explained, the supply of non-regular female and senior workers increased substantially in recent years. This change may have made capital input more expensive relative to labour input and slowed down capital accumulation. To measure the input cost of one unit of labour services, we use the following wage rate index:

Wage rate = Total labour costs/Total labour input index = Total labour costs/(labour quality index × Total hours worked)

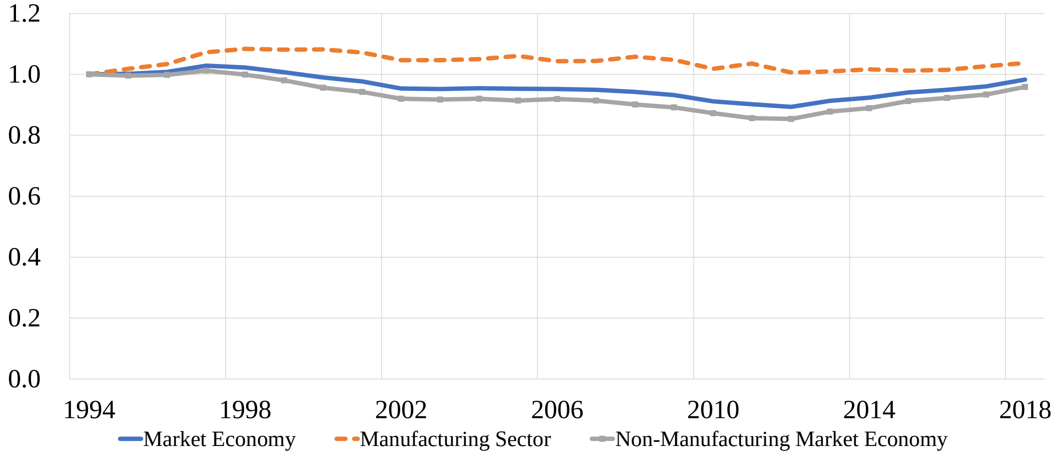
We obtain the data from the JIP Database 2021. Our wage rate index measures the labour costs incurred by firms (including social security expenses, accrued retirement benefits, etc., paid by employers) and takes account of changes in labour quality. As the rental price of capital, we use the same data as in Chart 4. Chart 5 shows developments in the wage rate and the wage-rental ratio (i.e., the ratio of the wage rate to the rental price of capital) during the period 1994–2018.

Reflecting Japan's very low or negative inflation and slow labour productivity growth, the nominal wage rate remained almost unchanged over the 24-year period. While the wage rate in the non-manufacturing sector declined somewhat until 2012, it subsequently recovered, essentially returning to the level at the beginning of the period. Meanwhile, as already seen in Chart 4, the rental price of capital followed a declining trend. Because of this decline in the denominator, the wage-rental ratio increased over time. In particular, it rose substantially until 2003–2004, mainly due to the decline in the rental price of capital as a result of unconventional monetary easing. The wage-rental ratio then stopped increasing during the period 2004–2011 because of the decline in the wage rate, the Bank of Japan's termination of its quantitative-easy policy and zero-interest rate policy, and capital losses on capital owned due to a decline in capital goods prices, which raised the rental price of capital slightly. From 2012, the wage-rental ratio started to once again increase quite rapidly. Reasons include wage increases brought about by Abenomics, increased unconventional monetary easing,

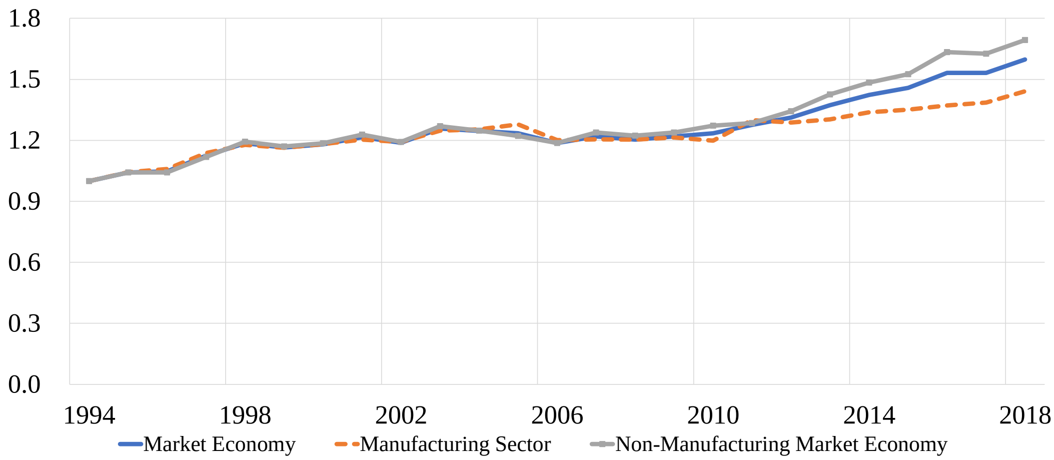
24 The depreciation of the yen also raised the prices of tradables, leading to an increase in the capital goods price index from 2012 to 2018. This change resulted in capital gains for capital owners and reduced rental price of capital.

Chart 5: Wage Rate and Wage-Rental Ratio in Japan: 1994–2018, (1994 = 1)

Panel A: Wage Rate in Nominal Terms



Panel B: Wage-Rental Ratio (Wage Rate in Nominal Terms/Rental Price of Capital in Nominal Terms)



Source: Authors' calculations based on the JIP Database 2021.

and capital gains on capital owned caused by the depreciation of the yen and increases in capital goods prices.

Since the wage-rental ratio increased substantially during 2012–2018, the slow capital accumulation during this period cannot be explained by the substitution of capital by labour.

To sum up the analysis above, the gradual slowdown in capital accumulation can probably be explained as the transition to a low growth economy as well as the increase in unconventional monetary easing. However, we cannot explain why Japan's capital stock growth rate during 2005–2015 was below the natural growth rate. We also cannot explain why capital accumulation did not accelerate substantially under Abenomics.

In the case of the United States, Gutiérrez and Philippon (2017) find that the rise in investment in intangibles appears to have reduced fixed investment relative to Tobin's Q. Miyagawa and Ishikawa (2021) arrive at a similar result for Japan. However, in Japan, the increase in Tobin's Q was modest and, as we will see in the next section, intangible investment excluding R&D and software is relatively small in comparison with the United States. It therefore seems that it cannot be argued that an increase in intangible investment (excluding R&D and software) substantially displaced other capital accumulation (including R&D and software) in Japan.

Gutiérrez and Philippon also point to concentration, globalization, and corporate governance issues (increased short-termism) as causes of the reduction in fixed investment in the United States. However, in Japan, there are few giant firms such as the Big Tech firms (Google, Amazon, Apple, etc.) that have a dominant position resulting in a high degree of market concentration. Moreover, using firm-level data from the Economic Census, Fukao *et al.* (2021) find that the average Herfindahl-Hirschman index and the four-firm concentration ratio in industries (both measured at the 4-digit industry level) declined during the period 2011–2015. Therefore, Japan's slow capital accumulation likely cannot be explained by market concentration.

Turning to globalization, Japanese manufacturing firms have actively relocated production abroad and in fiscal 2018 (from April 1, 2018 to March 31, 2019), for example, gross fixed capital investment, which does not include R&D, by Japanese manufacturing affiliates abroad amounted to 4.4 trillion yen, equivalent to 27.5 per cent of the total capital investment in Japan of all domestic manufacturing firms (Ministry of Economy, Trade and Industry (METI) 2020:12). Therefore, the hypothesis that the sluggish fixed investment in Japan is linked to globalization is a promising candidate. However, it should also be noted that in 2018, 60 per cent of total capital formation in Japan's market economy was in the non-manufacturing market economy (JIP Database 2021), and globalization in Japan's non-manufacturing sector is not substantial.

Finally, whether corporate governance issues could provide an explanation is an issue that we hope to examine using firm-level data in the future.

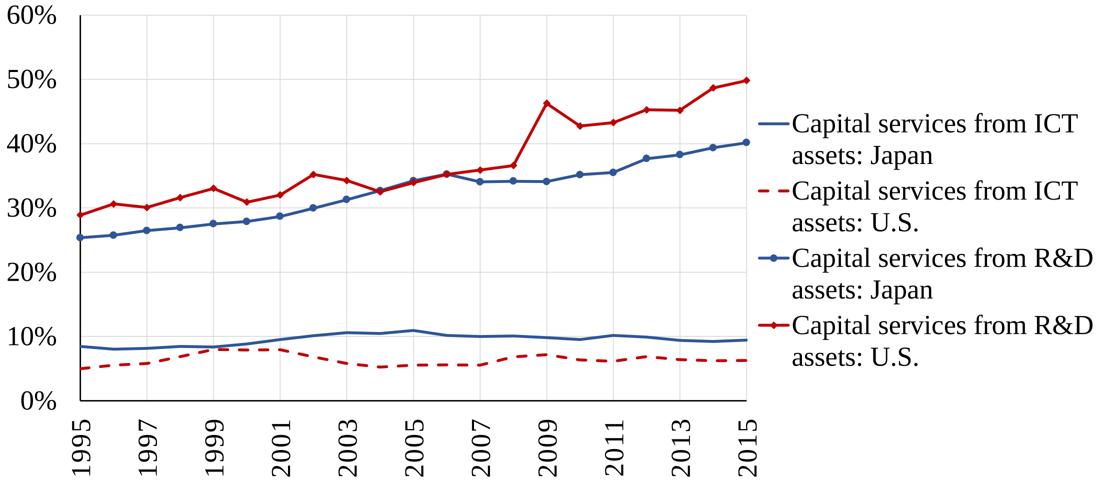
Input of Information and Communication Technology and Intangible Assets

One of the reasons for Japan's sluggish productivity growth that has been frequently highlighted is weak investment in information and communication technology (ICT) and intangible assets (see Fukao *et al.*, 2009, and Fukao *et al.*, 2016). In this section, we examine this issue primarily through comparisons of ICT inputs and intangible asset investment between Japan and the United States.

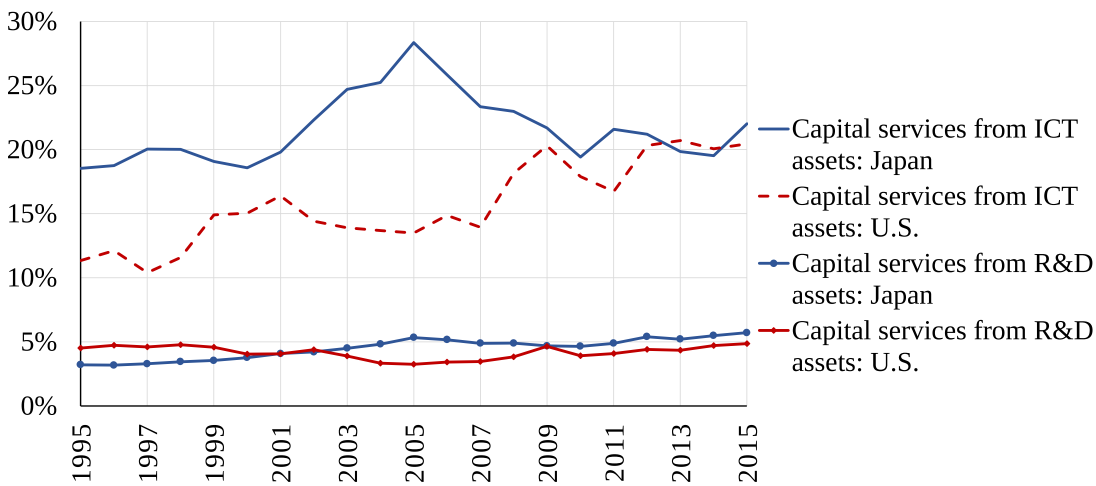
We start by comparing the share of ICT assets (including software), R&D assets, which form part of intangible assets, and other assets (total capital services input minus the services input of ICT and R&D assets) in total capital services input in the manufacturing and non-manufacturing market economy in Japan and the United States. In particular, we want to know whether the United States tends to have a higher share of ICT and R&D capital services input in total capital services input and whether Japan tends to have a higher

Chart 6: Share of R&D and ICT Capital Services in Total Capital Services Input by Sector: Japan-U.S. Comparison, 1995–2015

Panel A: Manufacture Sector



Panel B: Non-Manufacturing Market Economy



Source: See Table 3.

share of other assets.[25]

As shown in Chart 6, the share of R&D capital services in total capital services input is higher in the United States than in Japan in the manufacturing sector, but in the case of the non-manufacturing market economy, the shares in Japan and the United States are almost identical. On the other hand, the share of ICT capital services is higher in Japan than in the United

25 Capital services input by type of capital good for the United States was obtained based on EU KLEMS 2017 as follows: Capital services input = capital goods prices × (Nominal interest rate + capital depreciation rate + capital loss due to fall in price of capital goods) × Real capital stock, where for the nominal interest rate we use the annual average of 10-year Treasury yields, while for the capital depreciation rate, capital goods prices, and the real capital stock we use data from EU KLEMS 2017. In EU KLEMS 2017, capital goods for the United States are categorized into computing equipment, communications equipment, computer software and databases, transport equipment, and other machinery and equipment, total non-residential investment, residential structures, research and development, and other intellectual property protected assets. ICT assets are the total of the following three of these categories: computing equipment, communications equipment, and computer software and databases.

States both in the manufacturing and the non-manufacturing sector. However, in the non-manufacturing sector the gap has recently narrowed. These results suggest that the United States is not necessarily more ICT-intensive in its production activities than Japan. In addition, comparing the manufacturing and the non-manufacturing sector indicates that both in Japan and the United States the share of R&D capital services is higher in the manufacturing than the non-manufacturing sector;[26] on the other hand, the reverse is the case for the share of ICT capital services, which is higher in the non-manufacturing than the manufacturing sector.

Several comments are in order regarding the comparison between Japan and the United States based on Chart 6. First, in Japan, both the ratio of R&D expenditures to sales and the ratio of ICT capital services input to gross value added tend to be much lower for small and medium-sized enterprises (SMEs) than for large firms (see Yamaguchi *et al.*, 2019, for R&D and Fukao *et al.*, 2016, for ICT). Therefore, for SMEs, especially those in the non-manufacturing sector market economy, Japan likely lags behind the United States in the adoption of ICT (Fukao *et al.* 2012 and Fukao *et al.*, 2016).

Second, it has been pointed out that the prices of ICT assets and ICT services differ between Japan and the United States. As highlighted by Fukao *et al.* (2016), the prices of ICT assets and services tend to be higher in Japan. For example, since it is too costly for small firms to have their own ICT service division providing a full range of ICT services, having access to efficient vendors of ICT services is a key factor for procuring ICT inputs at a reasonable price; however, in Japan, the market for business process outsourcing (BPO), which includes outsourcing of ICT processes, is not well developed. According to METI (2014), the size of the BPO market in Japan was 663 billion yen in 2012, whereas in the United States it was 12 trillion yen in the same year.

Another factor which makes ICT inputs expensive for small firms is the difficulties they face in recruiting ICT experts, as already explained in the second section. And even in the case of packaged software, the price in Japan according to a survey by the Ministry of Economy, Trade and Industry (METI, 2013) in 2012 was 2.27 times higher than in the United States.[27] While price differentials at market prices likely have shrunk due to the depreciation of the yen since 2012, this depreciation is insufficient to offset such price differentials. While Chart 6 suggests that the share of ICT capital services is higher in Japan than the United States, in real terms the share may be lower once price differences are adjusted for.[28]

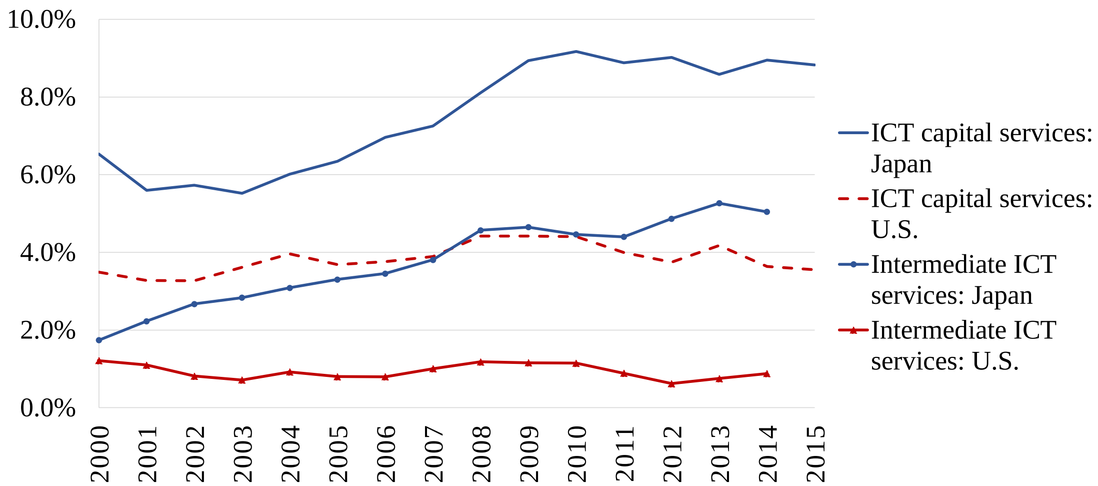
26 We should note that R&D does not play a major role in the non-manufacturing sector, except in ICT services.

27 It seems that packaged software suppliers employ a pricing-to-market strategy because of the lack of competitors and language barriers.

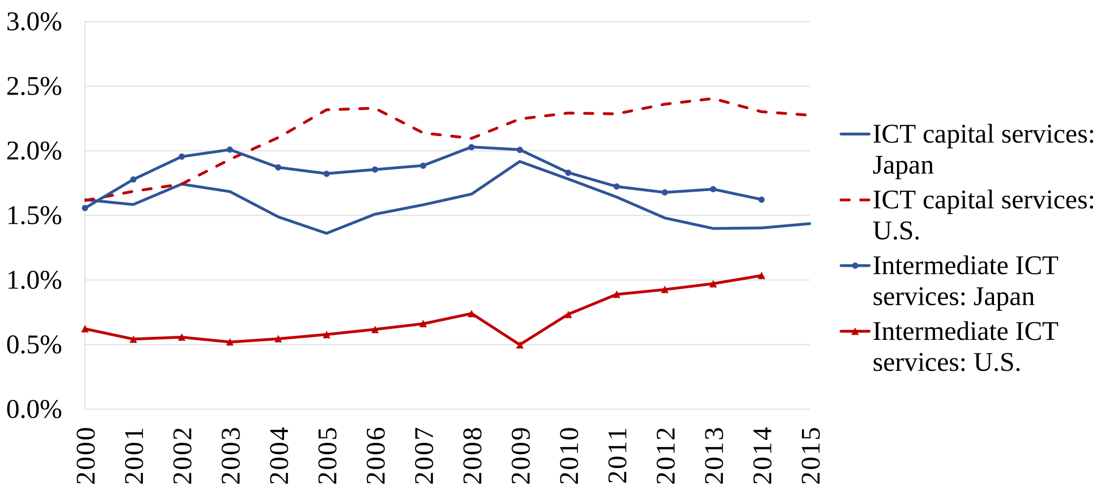
28 That is, if the elasticity of substitution between production factors is smaller than one, it is possible that the real price-adjusted input share of ICT capital services is lower in Japan than in the United States because the price of ICT capital is higher in Japan than in the United States, while the input share of ICT capital services in nominal terms is higher in Japan.

Chart 7: ICT Capital Services Input and Intermediate ICT Services Input Divided by Value Added in Japan and the United States: Finance, Wholesale, and Retail, 2000–2015

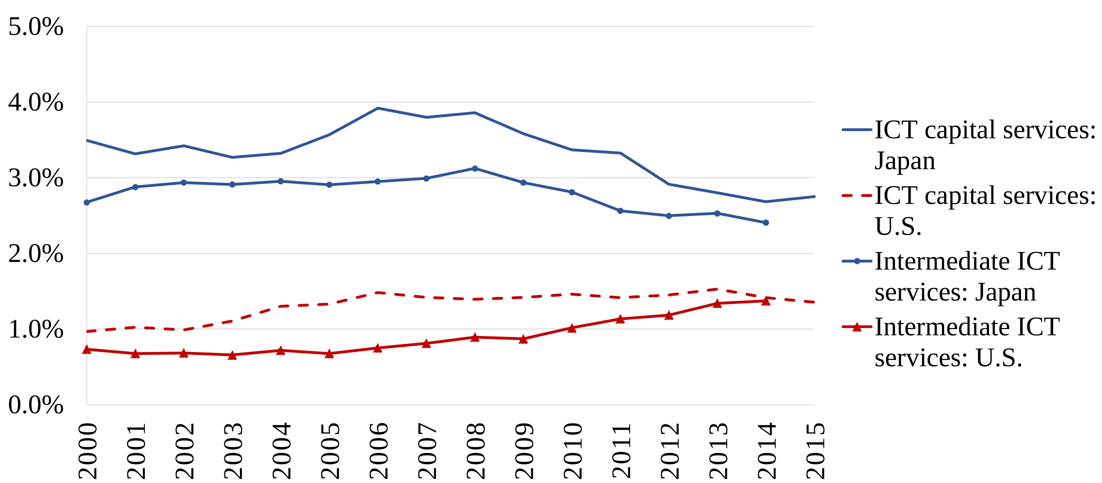
Panel A: Finance



Panel B: Wholesale



Panel C: Retail



Source: See Table 3 for the sources for ICT capital services and the denominator, value added. Intermediate ICT services were obtained from the 2016 release of the World Input-Output Database (WIOD; http://www.wiod.org/database/wiots16). Due to data limitations in the WIOD, this figure only covers the period from 2000.

Table 5: Real Capital Stock Growth Rates: Japan-U.S. Comparison by Type of Assets and Sector (annual rate, per cent)

	1995-2000	2000-2005	2005-2010	2010-2015
Japan				
Total capital stock				
Market economy	1.94	0.73	0.04	-0.01
Manufacturing	1.15	0.62	0.39	-0.16
Services	2.26	0.77	-0.09	0.04
ICT capital stock				
Market economy	10.14	5.34	2.18	1.12
Manufacturing	8.43	5.72	1.98	0.70
Services	10.62	5.24	2.24	1.23
R&D capital stock				
Market economy	3.02	1.81	1.42	0.70
Manufacturing	2.80	1.84	1.77	0.88
Services	3.88	1.66	0.02	-0.09
U.S.				
	1995-2000	2000-2005	2005-2010	2010-2015
Total capital stock				
Market economy	6.13	4.90	2.40	2.33
Manufacturing	4.39	2.24	1.73	1.69
Services	6.70	5.65	2.57	2.48
ICT capital stock				
Market economy	15.12	6.48	5.82	3.89
Manufacturing	13.69	0.74	5.22	3.05
Services	15.34	7.21	5.88	3.97
R&D capital stock				
Market economy	5.02	3.17	3.66	3.10
Manufacturing	5.11	3.81	4.13	3.04
Services	4.76	1.16	1.98	3.32

Source: See Table 3.

Chart 7 indicates that while in wholesale the value added ratio of ICT capital services is higher in the United States, in finance and retail it is about twice as high in Japan as the United States. The value added ratio of intermediate ICT services is about twice as high in Japan as in the United States in all three industries. Adding up the two ratios, we find that the sum of the ICT capital services and intermediate ICT services ratios is higher in the United States in the case of wholesale, but it is considerably higher in Japan than the United States in finance and retail. However, according to the survey of goods and services prices by METI cited earlier, ICT services are also much more expensive in Japan, with payroll processing fees and market research fees being 2.56 and 3.20 times higher, respectively. Therefore, as in the case of ICT assets, Japan may only appear to be more ICT-intensive due to such price differences.

Summarizing the analysis on ICT inputs, there is no evidence that Japan's ICT inputs are clearly lower than those of the United States, although the issue of price differences between Japan and the United States in terms of ICT capital services and intermediate ICT services needs to be borne in mind. However, as we saw in the previous section, Japan lags behind other major countries in terms of capital accumulation, and it may also be lagging behind in terms of the accumulation of R&D and ICT assets.

To examine this point, Table 5 compares the growth rates of real capital stock by type of assets and sector in Japan and the United States. The table shows that, as in the United States, the ICT capital stock and R&D capital stock in Japan have been growing at faster rates than the total capital stock. However, the growth rates of both the ICT and the R&D capital stock are much lower in Japan than in the United States.

Intangible assets can be broadly classified into innovative property based, for example, on past R&D expenditure, computerized assets such as software, and economic competencies such as investment in advertising and branding, organizational structure, and off-the-job training of workers. Since we have already examined R&D expenditures and software purchases, let us make an international comparison of economic competencies. Chart 8 compares ratio of investment in economic competencies to gross value added by sector for the same five countries as above. The chart indicates that investment in economic competencies in Japan is also extremely low compared to the other major economies.

Japan's accumulation of ICT and R&D capital has been very slow in recent years. However, we found that the share of ICT and R&D investment in total investment is not particularly low when compared with the United States. Moreover, the value added ratio of the sum of the ICT capital services and intermediate ICT services ratios is higher in the United States in the case of wholesale, but it is considerably higher in Japan than the United States in finance and retail. We also noted, however, that ICT service prices are substantially higher in Japan than the United States, so that the real input of ICP capital services in Japan might be smaller than that in the United States. To sum up, what is concerning for Japan's future growth is not that the technologies employed by firms are not ICT- or R&D-intensive, but that firms do not invest in general to begin with, that ICT services are expensive, and that SMEs have been left behind in terms of investment in ICT and R&D.

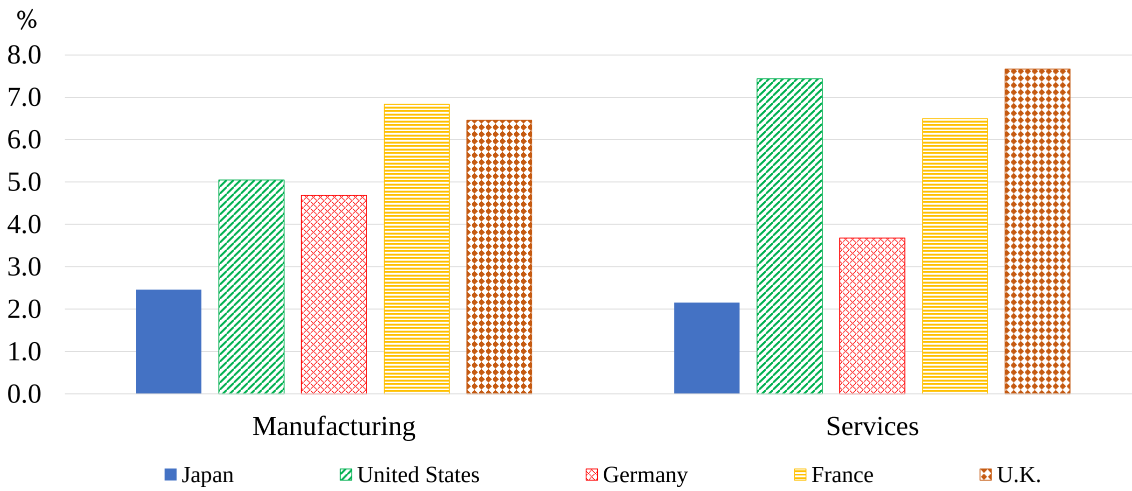
In Which Industries did TFP Growth Fall?

As shown in Table 1 in the second section, TFP growth in Japan's manufacturing and non-manufacturing sectors decelerated in 2005–2015 from already low growth in the preceding 10-year period from 1995–2005. To examine this slowdown in TFP growth, this section, using detailed industry-level data from the JIP Database 2018, examines which industries in particular were responsible for this decline in TFP growth. It should be noted that while Japan experienced a sharp fall in TFP growth around 1990, we cannot examine the reasons for this here, since the JIP Database 2018 covers only the period from 1994 onward.[29]

Chart 9 shows Harberger diagrams (Harberger, 1998) for the manufacturing sector for the periods 1995–2005 and 2005–2015.

29 A detailed analysis of the slowdown in TFP growth around 1990 using long-term data from the JIP Database 2015 covering the period 1970–2012 can be found in Fukao (2018b) for the manufacturing sector and Fukao (2018c, d) for the non-manufacturing sector.

Chart 8: Investment in Economic Competencies to Gross Value Added by Sector: International Comparison, 1995-2015



Source: Authors' calculations based on data from the JIP Database 2015 and INTAN-Invest (http://www.intaninvest.net).
Note: Japan data are for 1995-2012 period. Both investment in economic competencies and gross value added are in nominal terms.

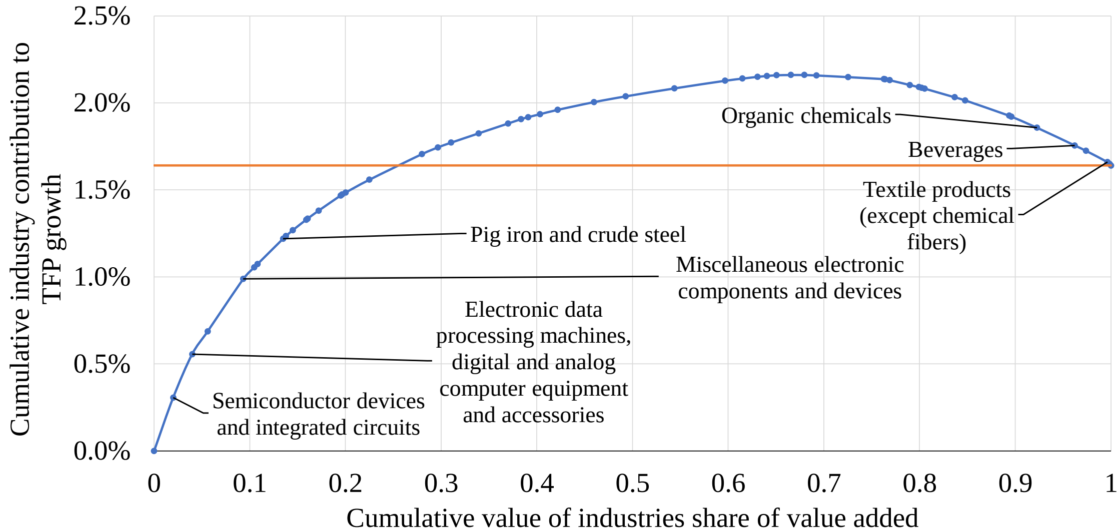
The vertical axes represent the cumulative industry contributions to aggregate TFP growth of the manufacturing sector (annual average, on a value added basis), while the horizontal axes depict the cumulative value of industries' share in the value added (average of each of the 10-year periods) of the manufacturing sector overall. The contribution of each industry was calculated by multiplying the TFP growth of that industry on a value-added basis by its share in the value added of the manufacturing sector overall. Industries are lined up by descending order of their TFP growth rate. Therefore, the slope of each line segment shows the TFP growth of that industry. We provide the names of industries that make a large positive or negative contribution to TFP growth in the manufacturing sector at the right end of the line segment.

Chart 9 indicates that the (annual average) TFP growth rate of the manufacturing sector overall declined from 1.6 per cent in 1995–2005 to 1.2 per cent in 2005–2015.[30] The value added weight of sectors with positive TFP growth was 67 per cent in 1995–2005 and 64 per cent in 2005–2015. The top three sectors in terms of their TFP growth contribution were (1) semiconductor devices and integrated circuits, (2) miscellaneous electronic components and devices, and (3) electronic data processing machines, digital and analog computer equipment and accessories in 1995–2005, and (1) pharmaceutical products, (2) semiconductor devices and integrated circuits, and (3) miscellaneous electronic components and devices in 2005–2015. In each period, these three sectors together contributed almost half of the TFP growth of the manufacturing sector overall. In other words, ICT hardware-producing industries were the main driver of TFP growth in the manufacturing sector.

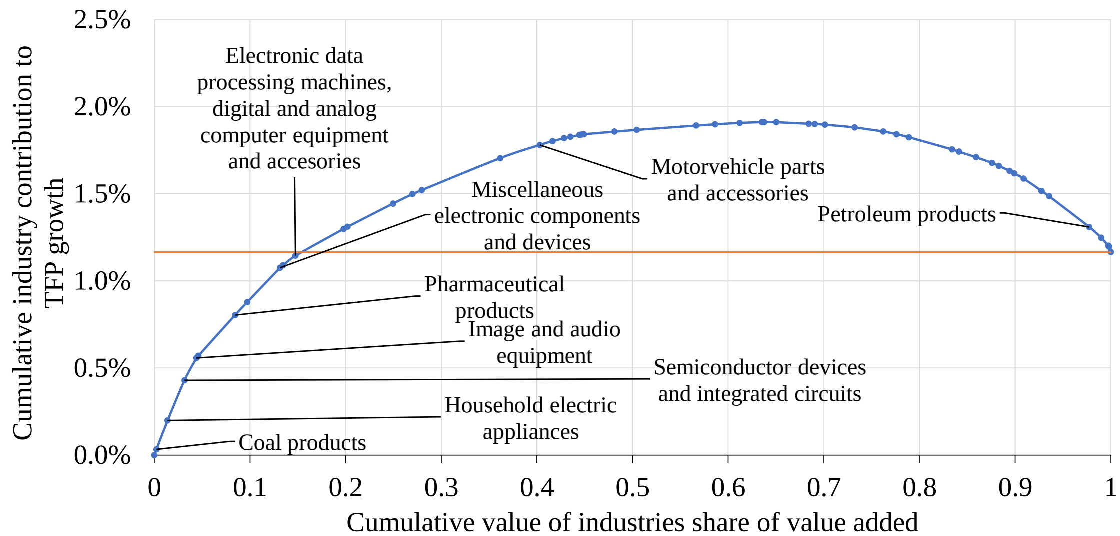
30 Because of aggregation error, these values are not identical to our growth accounting result in Table 1.

Chart 9: Harberger Diagram: Manufacturing Sector in Japan, 1995-2005 and 2005-2015 (Annual Rate, Percentage Points)

Panel A: 1995-2005



Panel B: 2005-2015



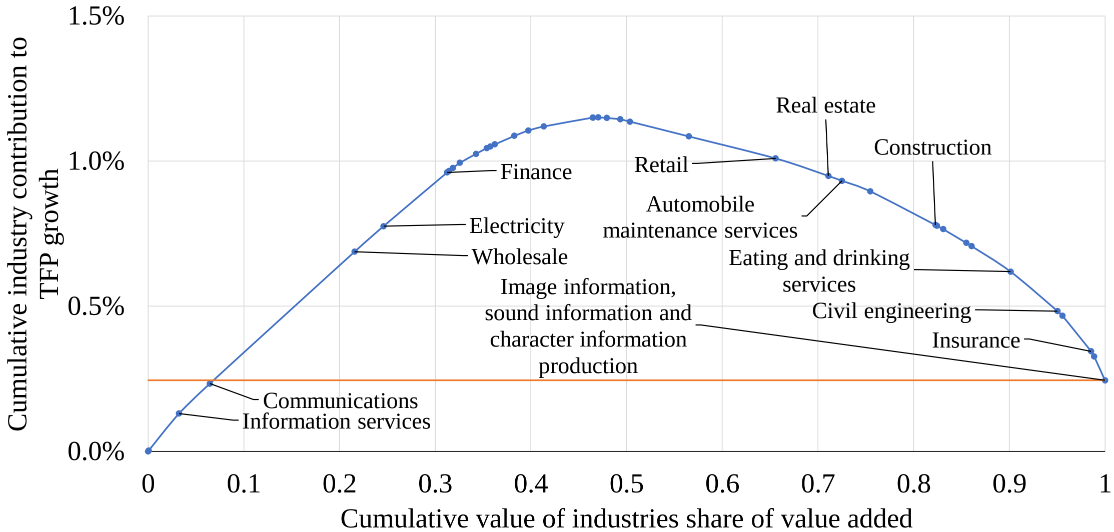
Source: Authors' calculations based on the JIP Database 2018.

The value added share of ICT hardware-producing industries (industry classification numbers 40–48 in the JIP Database 2018) in the manufacturing sector overall declined from 19 per cent in 1995 to 18 per cent in 2005 and 15 per cent in 2015. Moreover, their value added share in the economy overall declined from 5 per cent in 1995 to 4 per cent in 2005 and 3 per cent in 2015. This decline likely was one reason for the slowdown in Japan's overall TFP growth. However, compared with the United States during the period 2004–2013, the decline in Japan's ICT hardware-producing industries appears modest (Byrne, Fernald, and Reinsdorf, 2016).

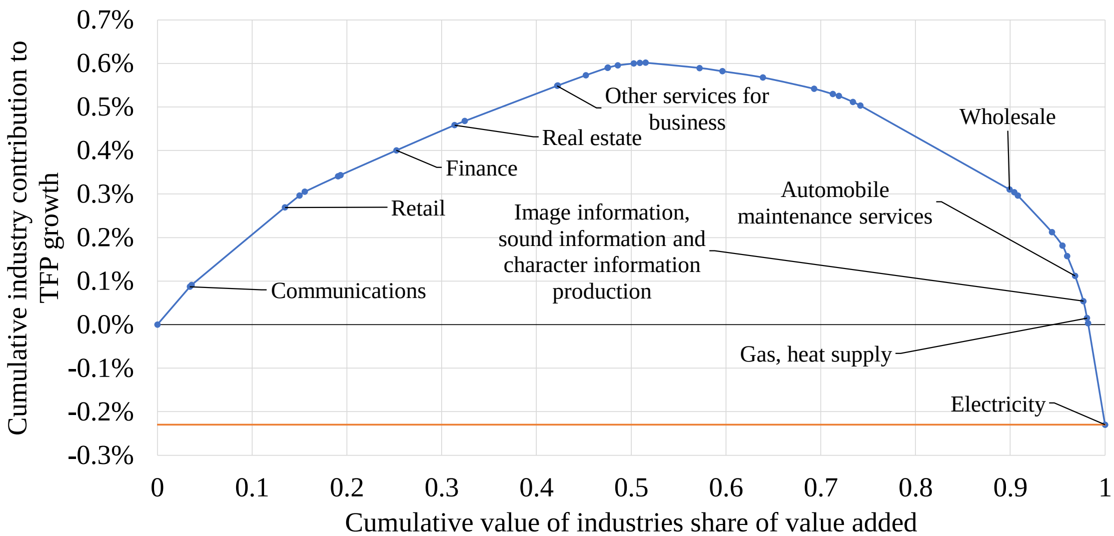
Chart 9 also shows that the industries that made a large negative contribution are mainly those in which Japan has lost

Chart 10: Harberger Diagram: Non-Manufacturing Sector in Japan, 1995-2005 and 2005-2015 (Annual Rate, Percentage Points)

Panel A: 1995-2005



Panel B: 2005-2015



its comparative advantage, such as textile products (except chemical fibers) and petroleum products.

Next, Chart 10 shows each industry's contribution to TFP growth in the non-manufacturing market economy as a whole for the periods 1995–2005 and 2005–2015.

As in the case of manufacturing, in both periods most of the TFP growth in the service sector was produced by a small number of industries. In 1995–2005, the combined contribution of the four industries with the largest contributions, wholesale trade, finance, information services, and communications, reached 0.9 percentage points per year. Similarly, during 2005–2015, the sum of the five industries with the largest contributions, retail trade, communications, other services for businesses, real estate, and finance, reached 0.46 percentage points per year.

Chart 10 indicates that TFP growth in

the non-manufacturing sector as a whole (market economy, services plus agriculture, forestry, fisheries, mining, construction, and utilities) fell from 0.2 per cent per annum in 1995–2005 to -0.2 per cent per annum in 2005–2015, and this decline can be attributed mainly to the slowdown in TFP growth in a small number of industries. The contribution of the wholesale, electricity, and information services industries fell by 0.6, 0.3, and 0.1 percentage points, respectively. On the other hand, the contributions of the retail trade, civil engineering, insurance, and real estate industries increased, but not enough to reverse the decline in TFP growth for the non-manufacturing market economy as a whole.

The sharp decline in TFP growth in the wholesale industry and the sharp increase in TFP growth in the retail industry likely reflect structural changes in the wholesale and retail sector such as the development of private brands by major retailers and the increase in online sales. Meanwhile, the sharp fall in TFP growth in the electricity industry likely reflects the fact that all nuclear power plants were shut down in the wake of the Tohoku earthquake in 2011.

Conclusion

Using the Japan Industrial Productivity (JIP) Database 2018 and 2021 and the EU KLEMS database 2017, we examined the sources of growth of the Japanese economy from a supply-side perspective and conducted comparisons with major industrialized economies. The main results of our analysis are as follows.

- The slowdown in Japan's economic growth in the 2005–2015 period compared to the 1995–2005 period was much more pronounced than that in the other major industrialized countries, reflecting not only the decline in the working-age population but also sluggish growth in capital services input.
- Among the major industrialized countries, only Japan's capital stock growth rate was lower than the natural growth rate calculated based on standard neoclassical growth theory.
- Comparing the composition of factor inputs in Japan and the United States, we found that although inputs of ICT and R&D capital services and intermediate ICT services in Japan are not particularly low compared to the input of other capital, capital investment in general has been extremely weak. Moreover, investment in economic competencies (worker training and organizational structure), which are thought to be complementary to ICT and R&D capital, has been much smaller than in other countries.
- In addition to demographic factors and sluggish capital investment, another reason for the slowdown in Japan's economic growth in 2005–2015 compared to the preceding decade was the decline in TFP growth, which was caused by a drop in productivity growth in a small number of industries such as electricity and wholesale trade.

The gradual slowdown in capital accumulation in the 1990s and the 2000s can probably be explained as the transition to a low growth economy as well as by the acceleration in the decline of the working age population and the increase in unconventional monetary easing. However, we cannot explain why Japan's actual capital stock growth rate during 2005–2015 was below the natural growth rate. We also cannot explain why capital accumulation did not accelerate substantially under Abenomics, a period when the rental price of capital declined and the wage-rental ratio increased.

A particularly unexpected result of our analysis is that economic growth in the United States and the other major industrialized countries after the global financial crisis was driven not by TFP growth but by increased capital input. From the 1990s, when Japan's prolonged stagnation began, to the early 2000s, authorities tried to maintain economic growth by promoting private investment through monetary easing and public investment. It appears as though the United States economy after the global financial crisis resembles Japan's economy during the 1990s.

However, it is also possible that although it has not yet resulted in higher TFP growth, the emergence of new technologies is generating vigorous investment. Fierce competition among companies trying to lead the so-called Fourth Industrial Revolution that is currently underway is triggering investment in R&D and ICT. For example, the total global R&D investment of Apple, Amazon, Microsoft, Intel, and Google in 2016 was approximately 7.2 trillion yen. This is more than half of the 13.3 trillion yen R&D investment by all Japanese firms together (according to the 2017 Survey of Research and Development).

In order for Japan, which has already fallen behind in the ICT revolution, to avoid the mistake of falling behind in the Fourth Industrial Revolution as well, Japan needs to promote investment in human capital to support large-scale investment in new technologies such as electric vehicles, automated driving, robots, the internet of things, artificial intelligence, fintech, and big data. Moreover, in order for Japanese firms to redirect their enormous internal reserves to investment, the government needs to reduce policy uncertainty and proactively reform laws and institutions that inhibit new innovation. It is no exaggeration to say that the first requirement for Japan to ride the Fourth Industrial Revolution, which presents a major opportunity for the economy to escape from long-term stagnation, is to make new investments.

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Measuring the Volume of Services Industries Output and Productivity: An Audit of Services Producer Price Indices in OECD Countries

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Abstract

This article discusses measurement of Services Producer Price Indices, which are important in estimating the volume of the output of services sectors. Price indices for 31 individual services activities were downloaded from the websites of National Statistical Offices for 16 OECD countries and compared to those for the UK. The results show that UK services prices tend on average to have either lower or equal price growth than in other countries, suggesting that an underestimate of services output growth is not likely to be a greater problem in the UK than in other comparable countries. Nevertheless, there may be common biases across countries due to inadequate adjustments for quality. Further analysis of measurement methods suggests a small but significant positive bias in price inflation for one commonly employed method based on time spent on the provision of services. This means that the growth in the volume of services activity may be understated in general in the group of countries considered in this article.

Introduction

In many countries aggregate productivity growth has increasingly been dependent on trends in services sectors, both due to declines in the share of manufacturing over time and in the concentration of many in-

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novations related to information technology, and more recently, digital technology, in services. For example, Timmer et al. (2010) present evidence for the importance of services sectors as drivers of productivity benefits from the use of information technology. Likewise, Lehrer et al. (2018) discuss how digital technologies, in particular big data analytics, provide a key organizational resource for services innovations. Measuring the productivity of service industries requires accurate measures of real output. For many privately provided service industries, surveys and censuses contain the necessary information on nominal output. The main measurement issue is the need to have reliable measures of prices to construct volume measures, which are comprehensive in their coverage and capture any quality changes in the provision of these services. Improvements to the Services Producer Price Indices (SPPIs), which feed into deflators of domestic output of service industries is a priority area for the Office for National Statistics (ONS) and is recognised as an important channel for statistical improvement internationally.

Several national and international initiatives have aided both our understanding of measurement methods and provided better estimates of SPPIs. ONS carried out a quality review of SPPIs, summarised in Thomas (2016). This recommended improvements in the quality and coverage of existing SPPIs, including "the introduction of rotational sampling in the SPPI survey to establish the SPPIs on a sustainable, methodologically-robust foundation," as well as the development of new SPPIs. The updated guide for developing statistics on SPPIs is based on Eurostat (2013), and more specifically on OECD/Eurostat (2014) which provides a detailed methodological guide on mechanisms that service industry providers use to price their outputs, possible data sources and a review of practice for a number of countries. The Voorburg Group reports contain more details of the discussions among National Statistical Offices (NSO) on ways to measure prices of service industry activities.[2]

Since there is considerable effort currently devoted by OECD, Eurostat and the Voorburg group to reviewing and improving methodologies and data sources, we do not attempt to duplicate this discussion here but instead undertake a systematic attempt to compare the resulting Business to Business SPPIs. We concentrate on international comparisons of producer prices for service industry activities using data that is in the public domain via downloads from NSO websites. We use price growth, relative to aggregate price movements, as our unit of analysis. This reflects the fact that, in contrast to traded goods, there are fewer market mechanisms that would lead to common price levels across countries for the same service. At the same time, we should not expect very large deviations in relative price growth, and any such deviations might indicate measurement issues

2 The Voorburg Group on Services Statistics was established in 1986 in response to a request from the United Nations Statistical Office to help in the development and production of services statistics. Its objective is the design of an internationally comparable methodology for measuring the constant dollar outputs of the service industries. Available at: http://voorburggroup.org/.

that need addressing. It might have been useful also to examine relative price levels using purchasing power parity prices (PPPs) but this was considered beyond the scope of this article which is concerned primarily with volume measures across time.

The article starts with the SPPIs produced by ONS and reviews them against similar metrics in other countries. This takes the form of normalising annual average price changes, relative to measures of country specific inflation, for specific services and describing these across a number of dimensions, such as country, time and measurement method. The aim is to understand the extent to which the UK prices deviate from the average across countries. The analysis is based on data for 16 countries and 31 separate SPPIs. The choice of SPPIs was driven by those available for the UK and the choice of countries was dictated by the availability of readily downloadable SPPI series. The time series extend from the early 2000s to 2017 but the coverage varies by country and type of service.

We then extend this analysis to include other factors that impact on relative prices. We take account of market structure, which might impact on mark-ups charged, and we also attempted to allow for differences in regulation of markets. Other influences on relative prices such as preferences/tastes are captured by the country dummy variables, as these are likely to be time invariant. Here we focus more on those business services where measurement is most affected by the use of methods that do not allow for productivity improvements as explained below. This concentrates on differences in prices when time based (TB) methods are used relative to model pricing (MP), which is a method that attempts to price a standardised service and so can capture productivity change. We then provide some general descriptive analysis, based on panel regressions, and controlling for market structure and regulation. In this more complete analysis, we find that the average difference in these two methods lead to about 0.3 to 0.4 percentage points per annum lower prices using MP. This might affect output growth in volume terms and productivity in industries that intensively use the former, such as Professional Services. The impact on aggregate productivity growth, however, is likely to be relatively small, given the size of these industries. The article then investigates a possible alternative method that employs opportunity costs to measure price change for professional services, where opportunity costs are estimated based on the provision of these services internally in firms. We do this for a small number of services where TB methods are currently used. The results are consistent with the findings from the regression analysis, indicating that prices may be overstated using TB methods, but we also note some shortcomings of such an approach.

Context

Early on Griliches (1992) pointed to the mismeasurement of output and prices in the service sector as a possible explanation for the productivity slowdown in the US in the 1950s-1980s. In fact, it is widely believed that the measurement of output and prices in services is non-trivial and tends to be more challenging than in commodities or goods. Griliches (1994) argued that, with services gaining more importance and accounting for more output over time, there is a risk that the quality of the national income statistics could fall.

OECD/Eurostat (2014) classify the mechanisms that service industry providers use to price their outputs into three broad groups: explicit output charged mechanisms where a fee/price is charged for a service based on the output provided; time-spent mechanisms, often named 'time-based' (TB), where an explicit fee/price for the service is charged and payable as a function of time spent delivering the services; and margin-pricing where no explicit fee is identifiable but instead is bundled within the price of another good or service. This review concentrates on the first two mechanisms. Therefore, we excluded wholesale and retail trade and financial services from the analysis as these service industries predominantly employ margin-pricing. These SPPIs refer to Business to Business transactions and do not include services sectors that mainly transact with consumers and government such as personal services, education or health. The services industries included in this article combined account for about 60 per cent of total services value added in the UK.

Although much methodological and practical progress has been made in measuring SPPIs in recent years, significantly increasing the availability of SPPIs across countries, measuring price changes in services remains challenging because of the way in which businesses supply and charge for services and the difficulty of identifying quality changes or separate price indices per end-user (OECD, 2018). It is difficult to track prices for repeated service transactions and approaches designed for repeated product transactions are generally less applicable. Services are often provided together with other services or with goods, requiring either these bundles to be broken down and priced individually or priced together. Either way, non-monetary benefits of the bundle will need to be taken into account in the price index and the components of the bundle will need to remain the same over time, either through incorporating quality adjustments or by updating the bundle's components.

Although the same quality adjustments for goods can also be applied to services, the implementation is more challenging as the service provision, delivery or structure may change over time (Loranger, 2012). Very often, the service is unique in nature which requires convention-based assumptions that seldom reflect real quality changes. Finally, due to data limitations, published SPPIs only refer to business to business and not business to consumers or exports. Although distinguishing between those users is a crucial requirement for national accounts when price discrimination is evident, it is a non-trivial task.

This article is based on ESCoE reports, O'Mahony and Samek (2018, 2021), that investigated if there is evidence that the UK measurement methods in producing SPPIs are systematically out of line with international best practice. These reports also investigated empirically the dependence of measurement of SPPIs on the methods employed more generally. The results presented below indicate that UK services price growth was, on average, lower than in most other countries, suggesting little evidence of a particular UK measurement problem. Given the UKs increasing

Table 1: Coverage of Services Producer Price Indices by Country

Country	No. of SPPIs	Country	No. of SPPIs
Australia	25	Italy	12
Austria	16	Netherlands	18
Belgium	8	New Zealand	8
Canada	11	Norway	17
Denmark	8	Spain	12
Finland	22	Sweden	23
France	28	United Kingdom	31
Germany	19	United States	26
		Total	**284**

Notes: Authors' compilation based on *number of individual SPPIs available to download in 2018.

reliance on service sectors, this in turn suggests that an underestimate of services real output growth is not likely to be an explanation of why productivity growth in the UK continues to lag that in other countries in recent years. However, this does not preclude common problems shared by all countries. If no NSO adjusts adequately for quality, for example, by using hedonics, then all suffer from a measurement issue.

Given that countries commonly use similar methodologies, we delve deeper into where bias might arise due to lack of quality adjustments. Based on both regression analysis and examination of alternative methods, we find a small but significant upward bias in price inflation using TB methods. This means that the growth in the volume of services activity may be understated in general in the group of countries considered in this article.

Data and Method

The starting point for the choice of price series is the UK services producer price indices produced by ONS. We then checked availability of equivalent series for other countries and extracted data from 2001 to 2017 for 284 separate SPPI series, although for many countries/services the series starts much later than 2001. We extracted data mostly by industry but sometimes by product to fill gaps.

Table 1 lists the countries included in this study and shows the number of price series available for each. By design the UK has the highest number of SPPIs – these cover industries that represent about 36 per cent of aggregate Gross Domestic Product (GDP). This is closely followed by France, the United States and Australia. A significant number of SPPIs on the UK list were also available for Finland and Sweden and more than half were available for Austria, Germany, the Netherlands and Norway. Fewer were available for other countries.[3]

Table 2 shows the list of SPPIs compared and the number of countries for which these

3 Readers may be surprised by the small number of SPPIs covered, given the size of the service industries in each of these economies and the heterogeneity of service products. This is especially true relative to other industries, e.g. manufacturing in the UK represents around 10 per cent of the UK economy yet it has over 950 PPIs. Some countries, such as the US, do have additional price indices which are not easily comparable with those in the UK. However, in general there is a clear need for more coverage of services activities and more granular measures within industries, in many of the countries considered in this article.

Table 2: Coverage of Services Producer Price Indices by Type of Service

Industry		No. of SPPIs	Industry		No. of SPPIs
4921:	Commercial Rail Freight	5	6820:	Property Rentals	8
4939:	Bus and Coach Hire	3	6830:	Real Estate Agency	8
4941:	Freight Transport by Road	15	6910:	Legal Services	10
5011:	Vehicle Ferries - Commercial Traffic	3	6920:	Accountancy	11
			7022:	Business and Management Consultancy	12
5020:	Sea & Coastal Water Freight Transportation Services	12	7111:	Architectural Services	10
5210:	Storage and Warehousing	14	7112:	Engineering Services & Related Services	10
5224:	Cargo Handling	11			
5229:	Freight Forwarding.	5	7120:	Technical Testing and Analysis	9
5310:	National Post/Parcelforce	8			
5320:	Courier Services	15	7312:	Advertising Services	10
5510:	Licensed Hotels and Motels with Restaurants. Business Customer	7	7320:	Market Research	8
			7732:	Renting Services of Civil Engineering Machines and Equipment	8
5620:	Canteens and Catering	5			
5810:	Book Publishing Services	5	7800:	Recruitment and Personnel Services	13
5920:	Sound Recording and Music Publishing Services	2	8011:	Security Services	13
6110:	Business Telecoms	11	8122:	Industrial Cleaning	14
6200:	Computer Services	15	8210:	Secretarial Activities	4
				TOTAL	**284**

Notes: Authors' compilation based on number of individual SPPIs available to download in 2018.

data were available. Some services had almost complete coverage, including freight transport by road, courier services, computer services and industrial cleaning services. Others have very few entries, for example bus and coach hire, sound recording and secretarial services. Nevertheless, the sample represents a reasonable cross-section by type of service and is not overly concentrated in any one industry. In total we have data on 3,383 observations on annual price changes in the dataset.

OECD/Eurostat (2014) lists various sources of data that can be used in constructing SPPIs. These include: actual transaction price (the price of a service actually paid in the market, inclusive of any discounts, surcharges or rebates); list prices; unit values calculated as the ratio of revenues to amounts sold; percentage fees; expert estimate; and input data. Given these sources OECD/Eurostat (2014) distinguish pricing methods used by national statistical offices. We attempted to classify SPPIs by type of measurement method, using information from national sources, as well as OECD/Eurostat (2014) and reports by the Voorburg Group (Exhibit 1). In many cases SPPIs were based on aggregates compiled from two or more measurement methods. We classified some of these mixed methods into groups, as noted below, and allocated prices to a method if more than 75 per cent of the prices used one method. If there were multiple methods where none were dominant, we classified the prices as a mixed method (MX). Finally, if there was no information forthcoming we classified as unknown (UN). In this way all prices were classified to one category.

The first row of Table 3 shows the coverage of price changes by measurement method, for all countries included in this article. The highest concentration is in RP and the lowest in PF. RP and CP are most heavily employed in transport services whereas MP and TB are most used in professional services. Again, there are ex-

Exhibit 1: Typology of Measurement Methods

RP	**Direct use of prices of repeated services**	This uses either real transaction prices, or sometimes list prices, of the same service product in successive survey periods.
CP	**Contract pricing**	Prices in long term contracts for the repeated delivery of similar services.
RPCP	**Direct use of prices of repeated services and contract prices**	This category refers to cases where SPPIs were calculated using a mix of RP or CP methods at the detailed price level.
PF	**Percentage fee**	This method calculates the price of the service as the product of the percentage fee and value of the product to which the fee relates.
UV	**Unit value**	This constructs prices as the ratio of revenue to quantities.
MP	**Model pricing**	This is based on the hypothetical price of a (representative) standardised service.
TB	**Time based**	This is where the price of a service is specified in terms of the time spent in its provision.
MX	**Mixed methods**	Where the method was identifiable but involved a mix of the above methods and there was no clear reason to allocate to one of these.
UN	**Unknown**	Where there was little or no information on the method used.

Source: Authors' computation

Table 3: Services Producer Price Indice Growth Rates Relative to General Inflation: Summary Statistics by Measurement Method (Average Annual Rate of Change)

	RP	**CP**	**RPCP**	**PF**	**UV**	**TB**	**MP**	**MX**	**UN**	**Total**
Share of methods (%)	25.6	7.2	9.4	3.3	4.9	13.8	8.3	15.9	11.6	100
Mean price growth										
Raw data										
Mean growth (% p.a.)	1.75	1.82	1.78	2.27	-1.83	1.88	1.15	1.42	1.30	1.46
St. dev.	2.98	5.19	3.00	3.94	7.10	2.18	2.87	3.20	2.52	3.51
Relative to GDP Deflator										
Mean growth (% p.a.)	-0.21	0.04	-0.28	0.37	-3.20	0.08	-0.26	-0.13	-0.27	-0.29
St. dev.	3.18	5.40	3.12	3.97	6.99	2.55	2.72	3.25	2.63	3.59
Relative to CPI										
Mean growth (% p.a.)	-0.13	0.12	-0.23	0.36	-3.46	0.15	-0.39	-0.21	-0.28	-0.28
St. dev.	2.92	5.20	2.75	4.10	7.06	2.16	2.72	3.12	2.59	3.45

Note: See Exhibit 1 for definitions of variables
Source: Authors' compilations

ceptions so that the measurement method does not map entirely into service activities. PF on its own was a relatively rare occurrence but featured more frequently as one of the methods in the MX group. About 12 per cent of the price changes were categorised to the UN group.

Table 3 also shows mean growth in SPPIs in the raw data. The SPPIs in our sample grew on average by 1.46 per cent per year, with prices for a number of methods showing lower growth, notably UV and MP. To aid interpretation, we also show the growth relative to measures of price inflation to abstract from country specific macroeconomic factors that might affect prices. Table 3 presents the results of using two alternative measures of general price changes, the GDP deflator and the consumer price index (CPI). These relative growth rates are mostly negative, suggesting lower price growth in service industries than in other industries of the economy. The exceptions are CP, PF and TB, which showed positive growth in relative prices, using either the GDP deflator or CPI to normalise. The UV mean relative price growth is a clear outlier, driven mostly by price falls in the telecommunications industry. These numbers are in percent per annum, so the averages are quite small. The difference between TB and MP suggests about a 0.35 percentage point lower price growth for the latter, when normalized by the GDP deflator and a larger difference when using the CPI.

In what follows we present results using the GDP deflator but note any differences when using the CPI or no normalization. Note that when both time and country fixed effects are included, as is the case in the later regressions, the results are invariant to the normalization used. Finally, in Table 3 the standard deviations are large relative to the mean, suggesting noticeable variability in the data depending on year, country or sector.

UK SPPIs in Comparative Perspective

Table 4 shows the number of observations by country. This largely reflects the availability of SPPIs in Table 1, but the countries where only a few SPPIs were available also reported these for shorter periods of time. The negative mean value overall says that service industry prices on average grew by 0.29 percentage points annum less than prices in general measured by the GDP deflators.

The reasons for this are likely to be complex, but might be linked to the SPPIs referring only to business to business, with different margins for business to consumer, as well as the usual explanations for variations in price changes such as the degree of competition and regulation. Here we are normalizing by the growth in general prices to abstract from inflation. For most countries the mean is negative, the main exceptions being Canada, Finland and Sweden with the United States showing no change on average. The average relative price declines were greater than the UK only in Italy, but there were only small numbers of observations for that country and this is dominated by abnormally large declines for telecommunications services.[4] If the CPI is instead used to normalize, or no normalisation is used, the UK continues to show price growth lower than for most other countries. These averages hide very large year-on-year variation for some services, as shown by the fact that the standard deviations reported in Table 4 are multiple times the mean, as previously noted when discussing Table 3.

A similar picture emerges if we restrict attention to the period from 2006, which is the starting year for a greater number of countries. If we restrict further to 2010 onwards, then on average prices decline marginally in the United States and the difference between the UK and France and the Netherlands is much smaller. Nevertheless,

4 In fact, the UK is currently revising its telecommunications prices to better account for quality change – see Abdirahman *et al.* (2020) for details.

Table 4: **SPPI Growth Rates Relative to GDP Deflator: Summary Statistics by Country (Average Annual Rate of Change)**

	No. obs.	Mean (% p.a.)	St. dev.
Total all countries	**3383**	**-0.29**	**3.59**
Australia	401	-0.37	3.31
Austria	176	-0.24	2.97
Belgium	97	-0.15	7.05
Canada	97	0.29	3.18
Denmark	87	-0.14	1.7
Finland	304	0.25	3.54
France	270	-0.41	2.3
Germany	215	-0.3	5.6
Italy	96	-1.79	3.93
Netherlands	201	-0.39	2.48
New Zealand	127	-0.2	2.94
Norway	186	-0.38	5.18
Spain	365	-0.02	3.17
Sweden	258	0.3	2.81
UK	412	-0.74	3.16
US	350	0.03	3.08

Source: Authors' compilations

average relative price decline by more in the UK than in most other countries.

Given the very large standard deviations relative to the mean in Table 4 it is worth looking at the results from panel regressions to obtain an idea of the significance of these differences across countries (Table 5). In this analysis we first removed a very small number of outliers, 12 in total, where price change was more than 20 per cent per annum in absolute values, reducing the sample to 3,371 observations. First, we regressed the growth in relative prices on the UK dummy in addition to year dummy variables to abstract from period specific effects, and dummy variables for the 31 SPPI codes. The regressions were carried out both for the entire time period and restricting to the 2006 and after period.

In the first two columns of Table 5 the coefficient on the UK dummy is negative and significant. This is even more so if the CPI is used as a measure of general price increases, with coefficients of -0.66 and -0.89 for the periods 2001-2017 and 2006-2017, respectively. The coefficients for the UK dummy remain negative and significant even if we do not normalize for general price movements. We then ran the same regressions but with the UK as the excluded country. The coefficients in the third and fourth columns are all positive, with the exception of Italy, with sizeable coefficients for the US, Canada, Finland, New Zealand and Sweden. These results are similar in the two periods. The availability of price indices before 2006 are confined to a few countries and mostly restricted to the transport industries. Overall, these results are consistent with equal or lower price changes in the UK, on average, than other countries.

Measurement issues still arise even if the UK broadly follows best practice, as there are many services where prices are measured poorly everywhere. The remainder of this article examines more closely these measurement issues.

Table 5: Regressions Results by Country: Dependent Variable is Growth in Relative Services Producer Price Indices

	2001-2016 (1)	2006-2017 (2)	2001-2016 (3)	2006-2017 (4)
UK	-0.50*** (0.16)	-0.53*** (0.17)	-	-
US	-	-	0.66*** (0.21)	0.66*** (0.23)
Australia	-	-	0.08 (0.20)	0.32 (0.23)
Austria	-	-	0.48* (0.27)	0.53* (0.28)
Belgium	-	-	0.34 (0.34)	0.34 (0.34)
Canada	-	-	1.05*** (0.33)	1.15*** (0.35)
Denmark	-	-	0.34 (0.35)	0.35 (0.35)
Finland	-	-	1.13*** (0.22)	0.94*** (0.24)
France	-	-	0.31 (0.23)	0.31 (0.24)
Germany	-	-	0.43 (0.25)	0.47* (0.26)
Italy	-	-	-0.61* (0.34)	-0.62* (0.34)
Netherlands	-	-	0.07 (0.26)	0.15 (0.26)
New Zealand	-	-	0.93*** (0.30)	0.82** (0.34)
Norway	-	-	(0.39) (0.26)	0.58** (0.27)
Spain	-	-	0.36 (0.33)	0.36 (0.34)
Sweden	-	-	0.94*** (0.23)	0.89*** (0.25)
Adjusted R2	0.13	0.13	0.14	0.15
No. of observations	3371	3018	3371	3018

Notes: Time and SPPI code dummies included in all regressions; Standard errors in parentheses; * , ** , *** significant at 0.1%, 0.05% and 0.01%, respectively.

SPPIs: The Impact of Measurement Methods

Results from Panel Regressions

It is well known that of the methods outlined above, those using TB methods do not allow for any productivity improvements in providing the services. In many professional services, the ONS and many other NSOs use TB methods. Therefore, it is useful to examine the change in prices in this method relative to others, especially MP which is commonly used for professional services.

Table 6 shows panel regressions when we include TB and MP, with all other methods of measurement as the excluded cate-

Table 6: Regressions Results by Measurement Method: Dependent Variable is Growth in Relative Services Producer Price Indices

	(1)	(2)	(3)	(4)	(5)	(6)
TB	0.43***	0.44***	0.37**	0.13	0.38**	0.14
	(0.14)	(0.14)	(0.15)	(0.17)	(0.19)	(0.21)
MP	0.10	0.11	-0.10	-0.16	-0.10	-0.16
	(0.18)	(0.18)	(0.19)	(0.21)	(0.24)	(0.25)
Year Dummies	NO	YES	YES	YES	YES	YES
Country Dummies	NO	NO	YES	YES	YES	YES
Service type Dummies	NO	NO	NO	YES	NO	YES
Adjusted R2	0.002	0.02	0.035	0.16	0.025	0.09
No. Observations	3371	3371	3371	3371	3371	3371
F-value for test TB = MP	2.92*	2.65*	4.86**	1.41	3.07*	1.06
Rho					0.25	0.2

Notes: Robust standard errors in parentheses. * , ** , *** significant at 0.1%, 0.05% and 0.01%, respectively.

gories.[5] This allows us to clearly see the difference in magnitude of the coefficients and to test for differences across the two. In general, the coefficient on TB is positive and significant, but that on MP varies more. Without any controls for time, country and year, the regressions imply a 0.34 percentage point per annum difference between price changes in TB relative to MP. This differential is unchanged when time dummies are included but becomes a little larger (0.44) when we include country dummies and a little smaller (0.28) when we include year, country and type of SPPI dummies. However, both TB and MP are concentrated in a few services types, so adding these dummies may be over controlling, as suggested by the insignificance of TB and MP in column (4).

The final two columns in Table 6 report the results if we correct for first order autocorrelation, but this has little impact in this sample. The difference between TB and MP is not precisely determined, due to the high standard errors noted earlier. Testing for the significance of these differences suggests that only in column (3) is the difference significant at the 5 per cent level but it is significant at the 10 per cent level in columns (1), (2) and (5). In turn this lends itself to a cautious interpretation that is merely suggestive of a difference in relative price growth using the two methods. Note the results are robust to using the CPI to control for general price movements in columns (1) and (2) and are of course the same when year and country dummies are included in columns (3) and (4).

We experimented with examining the sensitivity of the estimates to using different time periods, e.g. restricting the sam-

5 The relative coefficients on TB and MP do not depend on how many measurement categories we include, since the measurement method is a set of mutually exclusive dummy variables. However, the significance of the coefficients varies according to the excluded category.

Table 7: Regressions Results Including Additional Controls: Dependent Variable is Growth in Relative Services Producer Price Indices

	(1) Market Structure	(2) Regulation	(3) Industries MN
TB	0.14	-0.38	-0.15
	(0.18)	(0.32)	(0.14)
MP	-0.17	-1.51**	-0.51***
	(0.30)	(0.44)	(0.12)
Lfirmsize	-0.90***	-	-
	(0.15)		
Churn	-0.09	-	-
	(0.34)		
Small	-7.28***	-	-
	(1.18)		
PMR	-	0.03	-
		(0.17)	
Year Dummies	YES	YES	YES
Country Dummies	YES	YES	YES
R2	0.06	0.15	0.08
No. Observations	1643	321	780
F-value for test TB=MP	0.89	4.82**	4.37**

Notes: Robust Standard errors in parentheses. * , ** , *** significant at 0.1%, 0.05% and 0.01%, respectively.

ple to years from 2006, when most countries have some observations, or after the financial crisis. The relative coefficients on TB minus MP remain at about 0.30-0.40 in these regressions.

We next attempted to include other control variables to try to capture elements of market structure and regulation. It turned out to be quite difficult to find measures at the level of service detail covered by the SPPIs so we had to use measures aggregated to broad industry level. We included three measures from the Eurostat Structural Indicators database. The first is the log of the ratio of value added to number of enterprises, a measure of the average size of firms (lfirmsize). To this we added a measure of 'churn' within each industry, (births of firms minus deaths of firms /births of firms) and the share of enterprises with fewer than 10 employees (small). In terms of regulation there were fewer data available so we decided to use the OECD indicator for product market regulation in the services industries (PMR). Both the market structure and product market regulation indicators are available for shorter time periods and fewer countries than observations in our main database.

Table 7 presents the results. In the first column we include the three market structure indicators. Looking at column (1) we see that the difference between TB and MP is similar to previous estimates, 0.31, when all three market structure variables are included. However, the sample size is much reduced, to a little over half the size in the main database. The results on the difference between TB and MP are not overly sensitive to including these three variables one by one. Therefore, controlling for market structure appears to have little impact on the relative difference between TB and MP. The market structure variables themselves are all negative, with lfirmsize and small both highly significant. Both the churn and small variable can be seen as measures of greater competition so we would expect their coefficients to be negative. It is unclear a priori what impact lfirmsize would have on price growth.

The second column of Table 7 shows the results if we include the PMR indicators. These regulation indicators are available for only four professional services – accounting, legal, architectural and engineering services and so the sample size is reduced to a very small number. In this case, the difference between TB and MP is much larger, greater than 1 percentage point per annum, and is significant at the 5 per cent level. The small sample size does not allow any robust conclusions, but the results suggest that these services are worthy of more scrutiny. Finally, column (3) shows the basic results when we restrict the sample to just include components of industries MN, 'professional, scientific, technical, administration and support service activities', where time based or model based price measurement is common.[6] The results suggest again a similar magnitude to previous results, 0.34 percentage point difference between TB and MP. This result is not very different if market structure variables are included, but these variables are especially aggregated for this industry and are insignificant in the regressions.

SPPIs for Professional Services: The Use of Opportunity Cost Measures

A suggestion arising from discussions with ONS officials is to use a shadow price based on opportunity costs, rather than attempting to directly measure prices based on time rates. This is based on the idea that professional services purchased from the business services industries (MN) are frequently produced in-house by firms. Therefore, the opportunity cost is the amount these firms pay internally for these services. Our search of the relevant literature did not throw up any instances of this idea being used in price measurement. However, it seems an interesting avenue to explore so we investigated the growth in opportunity costs compared to prices for a small number of professional services. We based opportunity cost on the gross hourly wages paid to similar occupations to those covered by the relevant SPPI. We could only find information to match four of the SPPIs listed in Table 2: legal services (91); accountancy services (692); business and management consultancy (7022) and advertising services (7312). For each of these broad groups we compared the average annual growth in the UK SPPI with an index of hourly earnings using data from the Annual Survey of Hours and Earnings (ASHE), as labour costs are the largest input to these services. Changes to the standard classification of occupations meant that we could only start

6 Industry classification 691-732 and 78-821 in Table 2.

Table 8: Relative Services Producer Price Indices and Wages in Professional Services, UK, 2012-2017 (Average Annual Rate of Change)

	SPPI	Wages	Wages minus SPPI
Legal Services (691)			
Legal Professionals	2.75	3.76	1.02
All Legal occupations (1)	2.75	1.94	-0.81
Accounting Services (692)			
Chartered and certified accountants	2.89	1.37	-1.52
All accountants (2)	2.89	0.77	-2.12
Management Consultancy (7022)	0.31	1.09	0.78
Architectural Services (7111)	1.69	1.75	0.06
Advertising Services (7312)	1.58	1.07	-0.51

Notes: 1. Including legal professionals and legal associate professionals; 2. Including financial accounts managers, and financial and accounting technicians.
Source: Authors' compilations

the analysis in 2012 and our SPPIs are only available to 2017, so we are comparing over a relatively short period of time.

In Table 8 we show the difference between the annual average growth over the period 2012 to 2017 for the SPPI relative to its comparator. To measure in-house services that abstract from services sold on the market, we use the gross hourly wage rates in all sectors of the UK economy excluding the specific industry covered by the SPPI. For example, wages of advertising managers are for all industries other than advertising services (7312). Also, for two of the services we include both a narrow and broad occupation definition, using weights from ASHE to aggregate across occupations.

For all legal services, accounting (both narrow and broad definition) and advertising services the growth in hourly wages is lower compared to the current SPPI, and for architectural services there is little difference. The exceptions are management consultancy and legal professionals, where wages rise significantly more than the SPPI. The short time period prohibits any precise conclusions from this exercise, but it does appear broadly consistent with the earlier results that there may be an upward bias in price growth in services that use time-based methods for constructing the SPPIs.

There are a large number of caveats in using this opportunity cost approach as an alternative to the current method. First we are only using labour costs so there should be adjustments for costs of intermediate inputs and capital. Second the estimates in Table 8 are based on very small samples of data on hourly wages. We investigated using the Labour Force Survey as an alternative to ASHE but the number of observations was even lower and the hourly wages were consequently very volatile. Of greater importance is that the services produced in-house by staff classified to these occupations may be very different to that produced outside the firms. Firms may employ persons with legal training or accountancy training, but it is doubtful if their qualifications and tasks undertaken are equivalent to those for barristers, solicitors and chartered accountants working in independent firms. The fact that legal professionals, which are mostly barristers and solicitors, show much higher wage growth than for the aggregate across all legal occupations, lends weight to this concern and suggests the match is not as strong as we would wish. Firms outside the legal services industry rarely exclusively employ their own barristers. Therefore, even if better data were available, it would still be necessary to ensure we were comparing like-for-like.

Conclusion

The analysis in Section 2 of this article suggests that measurement of SPPIs in the UK are in line with standard practice elsewhere. Section 4 provides some evidence in favour of the argument that there is an upward bias in measures of SPPIs using TB methods. In the period under consideration, total factor productivity (TFP) growth in industries MN in the UK was about 1.8 per cent per annum over the period 2005 to 2015, using recent estimates from EU KLEMS. In these industries 8 of the 13 SPPIs are either wholly based on TB methods or have a significant share of prices using this method. Multiplying our result (approximately 0.35 percentage point bias in annual price growth in TB) by 8/13 yields an estimate of 0.22 percentage points as the 'missing productivity' from using TB based methods. Correcting this bias would raise productivity growth in this industry to 2.01 per cent per annum, an upward adjustment of about 12 per cent. Raising productivity growth by this much is an important adjustment for industries MN, but has a much smaller impact on aggregate economy TFP growth. Industries MN account for about 12 per cent of GDP. Adjusting the aggregate deflators to take account of these adjustments to industries MN would raise total economy TFP by 0.022 and the market economy by 0.034 percentage points per annum. This is small relative to the nearly 1 percentage point slowdown in TFP growth comparing 2005-2015 to the previous decade and so contributes very little to explaining the productivity slowdown.

The article also explored using measures of opportunity cost as an alternative to TB methods, where opportunity cost was measured using wages of people in professional services occupations in outside industries. The results for some services are consistent with a bias due to using TB methods, but this is not the case for all services where such comparisons were feasible. There are concerns that the services produced in-house in firms are not comparable to the tasks performed by external suppliers. While an interesting idea, it is unlikely that the data will become available that would show a convincing use of opportunity cost for like-for-like services.

In order to meet the requirements of the Framework Regulation Integrating Business Statistics (FRIBS), SPPIs for EU countries will need to change from a business to business and government to a business to all basis, including final consumers and exports. O'Mahony and Samek (2021) considered available data for France and the United States on extending the current focus on business to business prices to include also business to consumers or exports. The data suggest there are some services for which price growth appears to be very different between services sold to businesses and those to consumers or exported. It would be surprising if these differences were due entirely to measurement methods and the most likely explanation is that firms and consumers are purchasing different services. In turn this also implies that an increase in the granularity of the supply-use framework might focus on differentiating between business and consumer goods. This aspect of the measurement of services prices warrants further investigation. In addition further work might extend the analysis to other industries such as wholesale and retail trade and financial services which use margin pricing.

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ViewPoint: Canada Should Establish an Equitable Growth Institute

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Abstract

Canada faces serious economic challenges and needs strategic policy advice to succeed. Productivity growth must rise from the mediocre trend of recent decades. The spoils of growth should be more evenly distributed. As a carbon-intensive economy, the adjustment to net zero emissions will require fundamental change. The Government of Canada has benefited from advice from occasional advisory groups, but it has been decades since there has been a comprehensive, multi-year policy research effort. The time has come to establish an Equitable Growth Institute. It should align with the objectives of the Government but have sufficient independence to tackle tough issues. Provinces and territories must be involved as they hold many of the policy levers. In addition to having its own governance structure and researchers, it should bring together and where appropriate create networks of researchers. The Institute should delve into big questions of the day, including whether and how a Quality of Life framework can inform decision-making and whether there are trade-offs or complementarity between economic growth and equity and sustainability objectives.

Canada's weak economic growth prospects threaten the well-being of Canadians and compromise the ability of Canadian governments, at all levels, to lower the very large debt burdens being amassed during the pandemic.

The April 21, 2021 federal Budget (Finance Canada, 2021a) provided two long-term projections assuming 1.9 per cent and 2.1 per cent annual average growth respectively. Both exceed the long-term growth rate of 1.7 per cent in the last Finance Canada (2018) long-term projection published in 2018. Drummond and Laurin (2021) find the underlying assumptions behind the Budget scenarios optimistic and argue recent trends could combine with future demographics to generate only about

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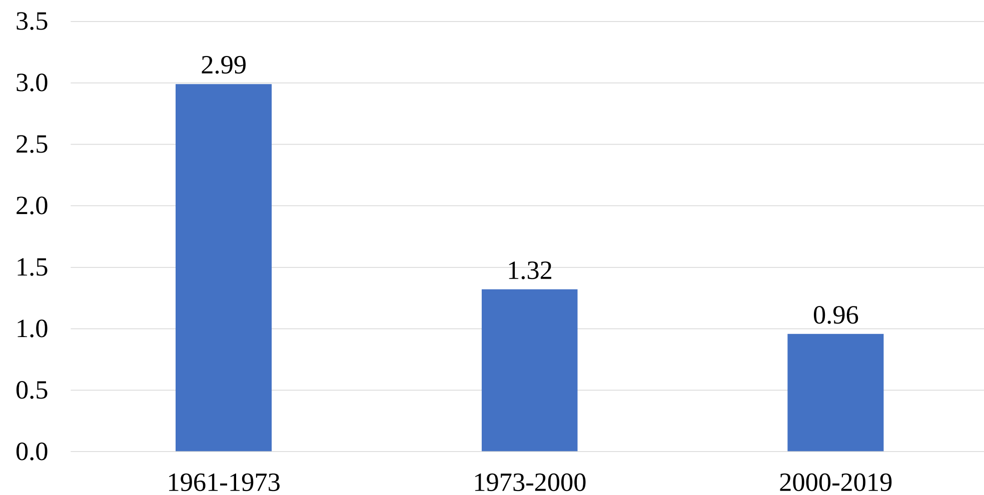
Chart 1: Total Economy Output Per Hour Growth in Canada, 1961-2019 (average annual per cent change)



Source: Aggregate Income and Productivity Trends: Canada vs United States, Centre for the Study of Living Standards. http://www.csls.ca/data/ipt1.asp.

1.5 per cent real growth in Canada over the next few decades (2026 to 2055). This would be similar to the growth rate projected in research done for the Council of the Federation in 2015 by the Centre for the Study of Living Standards (Drummond and Capeluck, 2015) that estimated the growth potential to be just slightly more than 1½ per cent.

The main reasons for such low growth are the aging population slowing labour force growth and a continuation of a long trend of modest productivity gains. Since 2000 Canada's labour productivity growth rate has averaged less than 1 per cent per annum, down sharply from the averages of 3.0 per cent 1961-1973 and 1.3 per cent 1973-2000 (Chart 1).

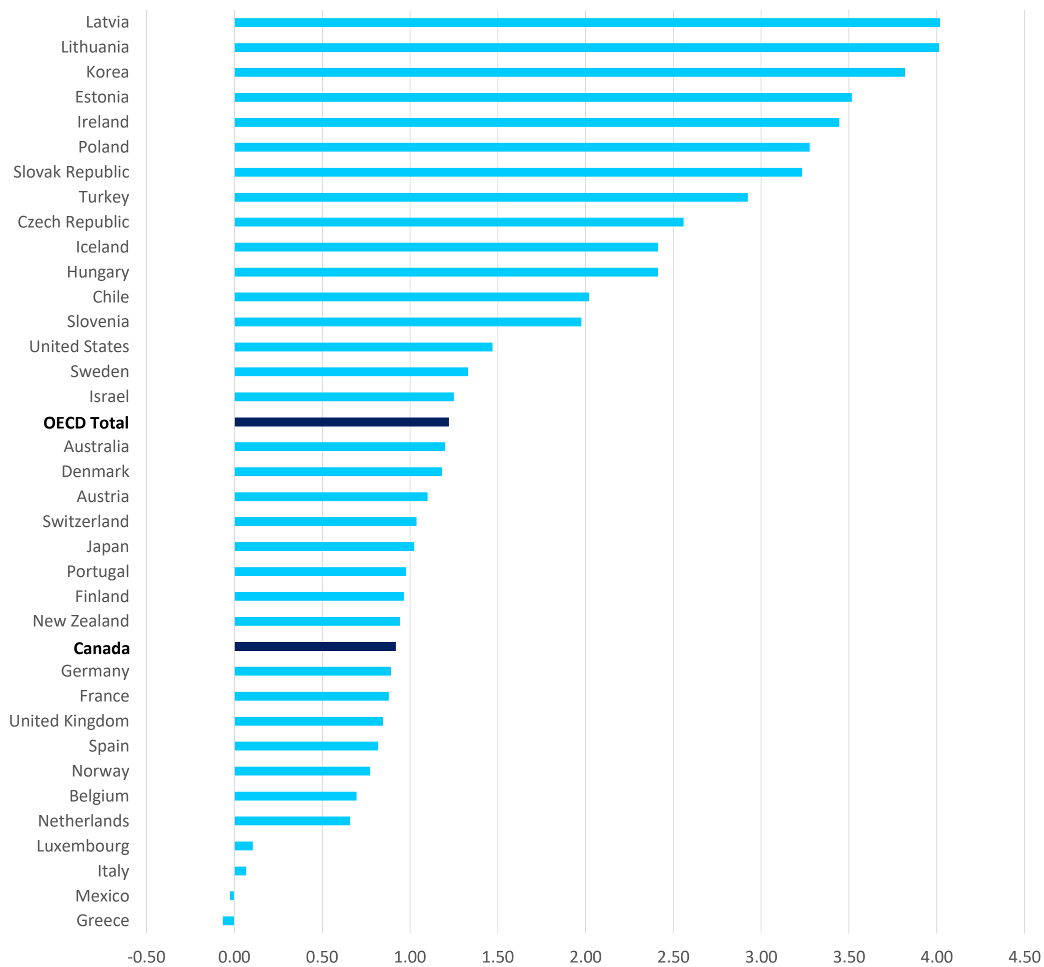
Over the past two decades Canada looks especially bad from the international perspective. Our labour productivity growth since 2000 has been 25th out of 36 OECD countries (Chart 2). The poor productivity performance has resulted in Canada's output per capita in 2019 falling 3.4 per cent below the OECD average, 11.4 per cent below the eurozone average, and 26.6 per cent below the United States.

The level of business sector productivity in Canada was 90-95 per cent that in the United States through the 1970s and into the early 1980s but has slipped since to only 70 per cent (Chart 3). Canada's modest labour productivity reflects increases in the capital stock rather than what might be thought of as innovation. If we strip capital expansion out and look at total factor productivity the Canadian record appears even worse with a slight decline since 2000.

The increase in income inequality in Canada in the last quarter of the 20th century was at least arrested in the 2000s, but little progress has been made since in narrowing inequality (Chart 4). Canada was roughly in the middle (18th of 37 OECD countries) in terms of inequality of income after taxes and transfers in 2018 (Chart 5). However. Canada can and must do better on growth and its distribution.

The Government of Canada estimates

Chart 2: Total Economy Output per Hour Growth in OECD Countries, 2000-2019 (average annual per cent change)



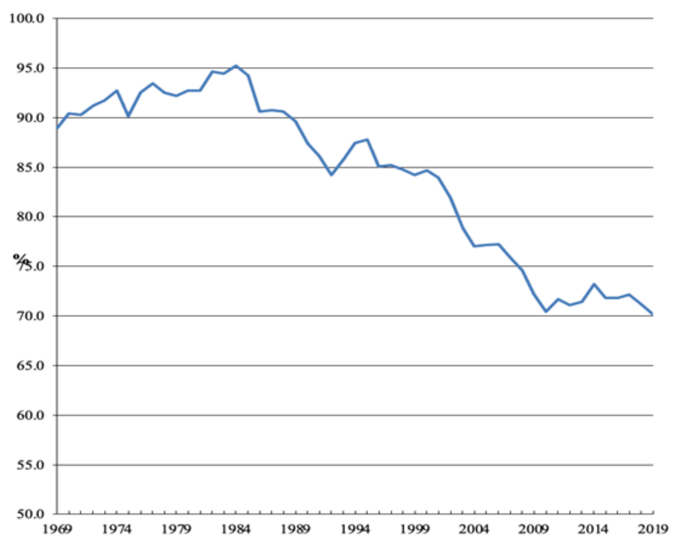
Source: https://stats.oecd.org/Index.aspx?DataSetCode=PDB_GR

existing plans, including actions in the April 2021 Budget, will reduce greenhouse gas emissions 36 per cent below the 2005 level by 2030. This leaves a significant gap to the target of a 40-45 per cent reduction. Further, the government has made a commitment to net zero emissions by 2050. It will be important to ensure the environment goals are achieved in a manner that is compatible with a strong economy.

The April 2021 Budget illustrates the sensitivity of fiscal prospects to the rate of economic growth. Lowering the average growth rate just 0.2 percentage points per annum adds 10 percentage points to the net debt-to-GDP ratio in 2055. Drummond and Laurin (2021) demonstrate that with just slight tweaks to the growth and interest assumptions the debt burden could rise from today's level of a bit over 50 per cent rather than falling to the pre-pandemic level of around 30 per cent in the Budget's favourable scenario.

Canadian governments, federal, provincial and local, need to intensity efforts to orient policy toward creating stronger growth and improving its distribution. Internal efforts have been buttressed in the

Chart 3: Relative Labour Productivity Levels (GDP per Hour) in the Business Sector in Canada, 1969-2019 (Canada as a % of the United States)



Source: CSLS estimates

past by asking advisory bodies to opine on Canada's growth problem and some recommendations have been adopted. The most recent effort was by the Advisory Council on Economic Growth (2018), chaired by Dominic Barton and reporting to the Minister of Finance.

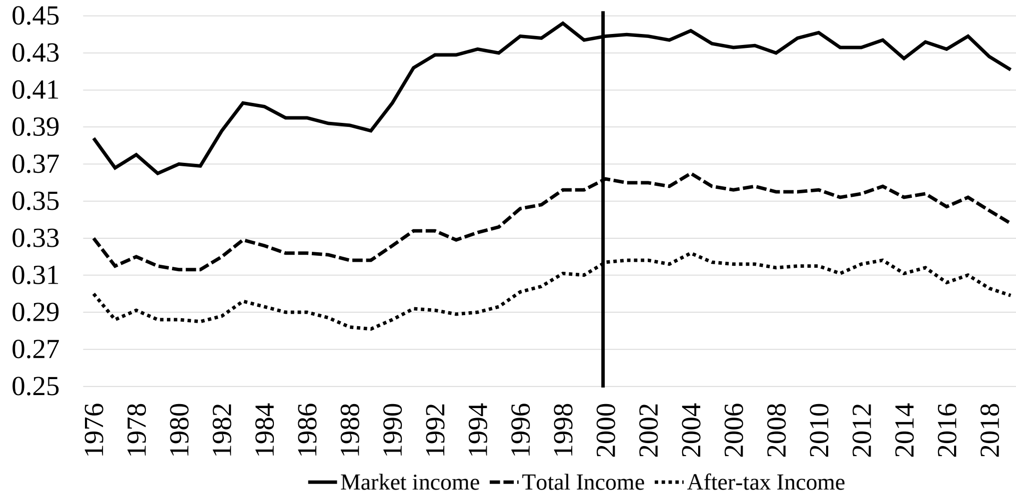
The Council provided sound ideas, but Canada's economic challenges require a deeper, broader and longer-lasting initiative – one that can do more extensive research, consult more and speak with stakeholders in the Canadian economy in the hope of building a consensus on the country's economic future. The economic future will likely be so dynamic, with the adjustment to a lower-carbon future just one of many fundamental shifts likely to happen, that it seems unlikely a temporary body can recommend a one-time re-set that will put the Canadian economy on a promising path for years. Adjustments will be required to address the ever-changing economic landscape. An Equitable Growth Institute could be designed to be permanent or at least have a multi-year horizon.

Learning the Lessons from Other Countries

As part of their attempts to strengthen economic growth, a number of other countries have created permanent research bodies on productivity or economic growth more broadly. A Canadian Equitable Growth Institute could benefit from the experiences. Dougherty and Renda (2017) analyzed and compared ten institutions and draw eight lessons from interviews with subject matter experts.[2] It should be noted that the lessons flow from a subjective

2 Australian Productivity Commission, Chilean Productivity Commission, Danish Productivity Commission, European Political Strategy Centre, France Strategie, Mexican Productivity Commission, New Zealand Productivity Commission, Norwegian Productivity Commission, US Council of Economic Advisors and Irish Competitiveness Council.

Chart 4: Gini Coefficients of Adjusted Incomes in Canada, 1976-2019



Source: Table 11-10-0134-01, Statistics Canada

methodology and are not based on analysis of what the advisory bodies might have contributed in terms of raising productivity.

The lessons are:

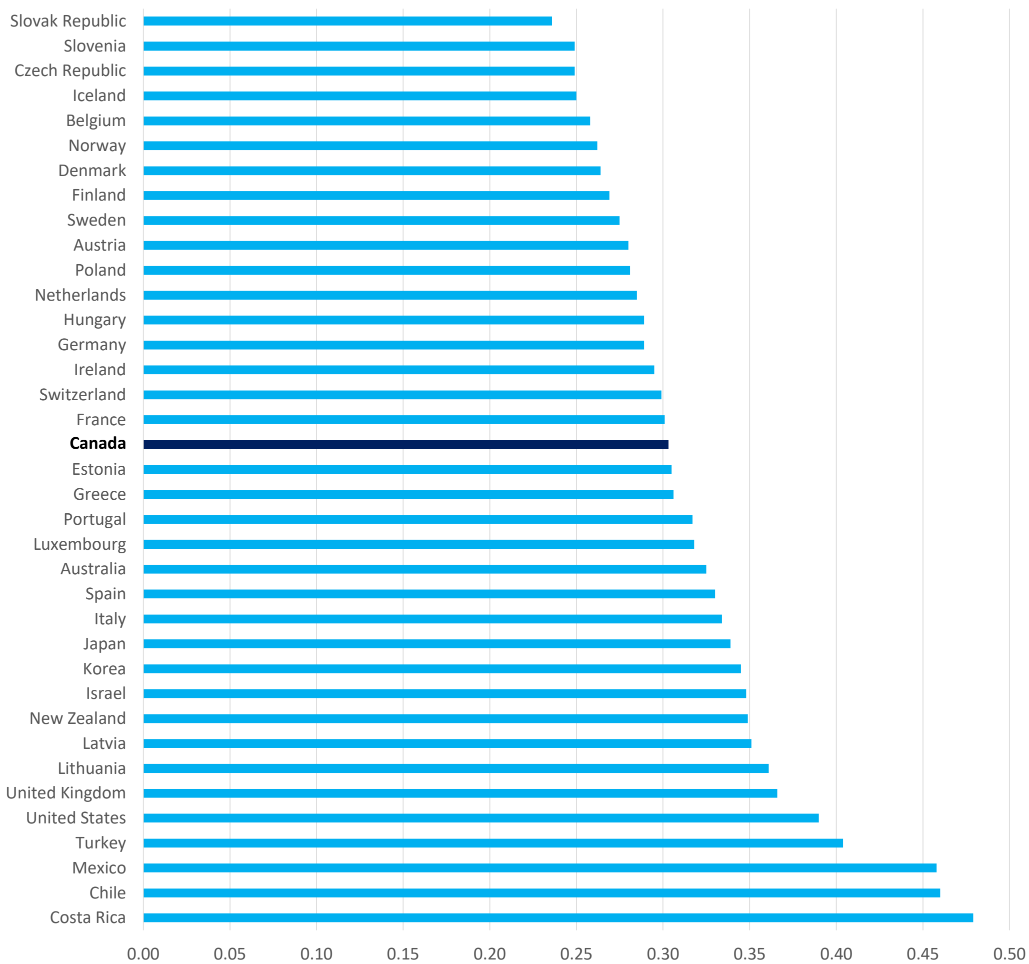
- Context matters: there is no one-size-fits-all solution when it comes to pro-productivity institutions.
- Pro-productivity institutions are no panacea: they should be part of an effort to embrace good governance and evidence-based policy-making.
- Political commitment is essential.
- Independence is important, although its extent can vary depending on the circumstances.
- Budget and human resources must be sufficient for high-quality research and quality control.
- Institutions should engage with stakeholders.
- It is important to combine short- and long-term thinking in the institution to preserve legitimacy and salience.
- Pro-productivity institutions should be "plugged into" the policy process.

Fitting the Canadian Context on What Matters

The advice that context matters should be key in designing an Institute for Canada. That starts with the objectives for the economy. While some other permanent advisory bodies are focused almost exclusively on productivity, that does not seem to fit the Canadian context. To be sure, improving productivity is necessary in Canada and should be a prime focus of the Institute. But Canadians are also concerned about the equitable and inclusive nature of the gains from economic growth and the sustainability of growth in terms of the environment.

Even on economic growth, the Canadian context calls out for a broader focus than only productivity. Canada has a fairly high labour force participation rate by historical and international standards, but it could be higher. This is particularly the case for the large and growing Indigenous population. If the Indigenous labour force participation rate gaps close and the trend toward declaring Indigenous heritage con-

Chart 5: Gini Coefficient in OECD Countries, Post Taxes and Transfers, 2018

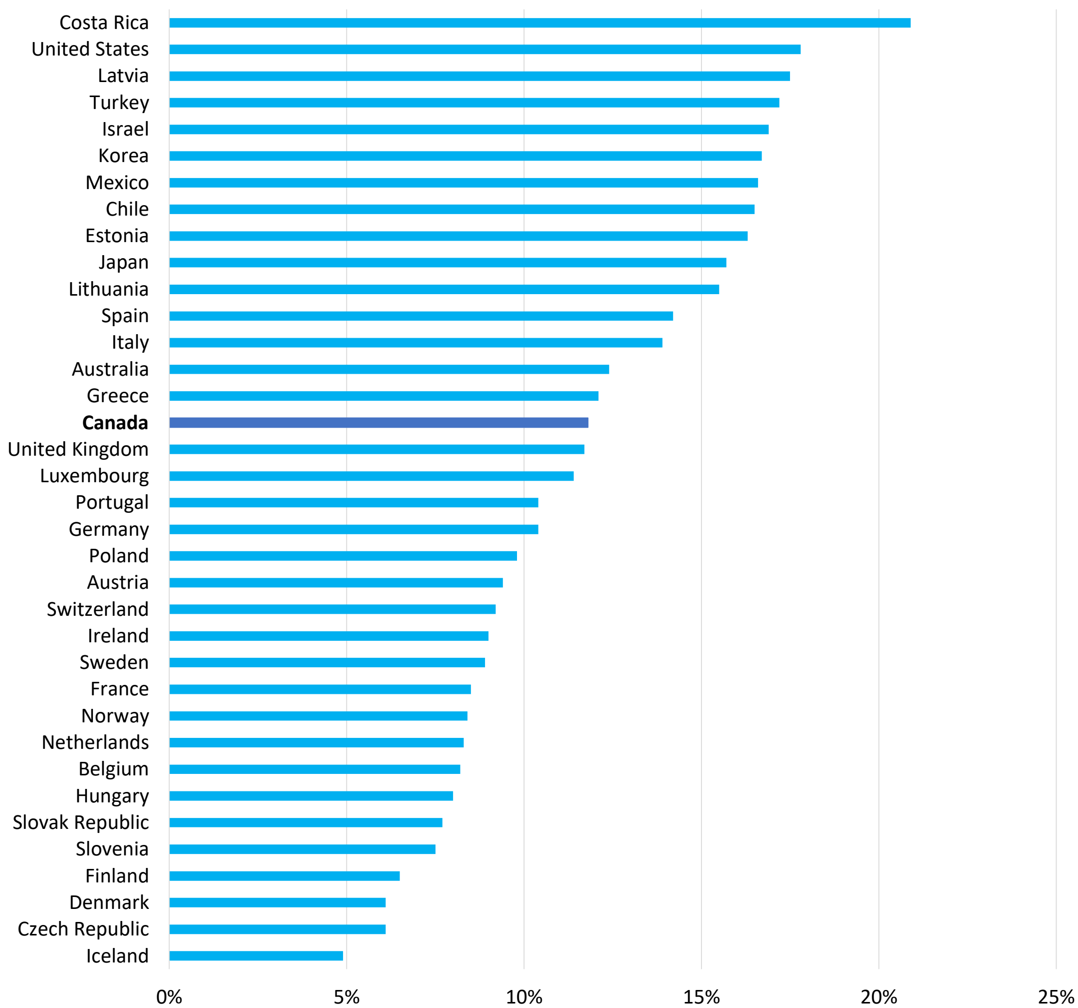


Note: Data for Chile, Denmark, Germany, Greece, Hungary, Iceland, Ireland, Italy, Switzerland and United States are for 2017. Data for Japan and Turkey are for 2015. Data for New Zealand is for 2014
Source: https://stats.oecd.org/Index.aspx?DataSetCode=IDD#.

tinues, Indigenous people will contribute more than one-fifth of all the labour force growth in Canada through 2036 (Drummond, Sharpe, Murray and Mask, 2017). The COVID-19 experience has heightened attention to the effect of childcare on female labour force participation. Immigration to Canada cratered during the pandemic. It will return on its own accord once travel and other restrictions ease, but rebuilding must address pre-pandemic challenges. While immigrants had been faring better in the labour market on the basis of several indicators from 2006 to 2019, the unemployment rates of new immigrants were persistently above those of other Canadians and their average hourly wages persistently lower (Wong, 2020). On the wage front, it is particularly troubling that highly educated recent immigrants fared worst in terms of the gap with respect to the Canadian-born.

The participation rate of persons with disabilities is 55 per cent in the prime working-age group 25-54 compared to 84 per cent for persons without disabilities (Turcotte, 2014). Higher participation of persons with disabilities could add hun-

Chart 6: Poverty Rates in OECD Countries, 2018



Notes:

1. Data for Denmark, Germany, Hungary, Iceland, Ireland, Italy, Switzerland, United States and Chile are for 2017. Data for Mexico and Netherlands are for 2016. Data for Turkey and Japan are for 2015.
2. The poverty rate is the proportion of the population whose income falls below the poverty line, which is defined as half the median household income of the total population. The poverty rate is measured after taxes and transfers, and income is adjusted for household size.

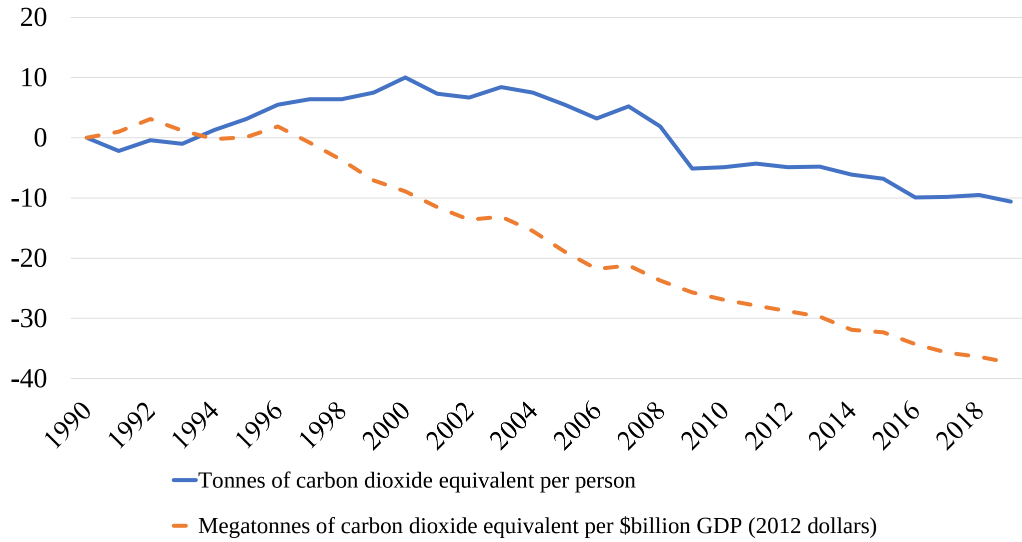
Source: https://data.oecd.org/inequality/poverty-rate.htm#indicator-chart.

dreds of thousands to the total labour force and be critical to improving their well-being.

Surveys suggest many older Canadians wish to continue working in some fashion, but not necessarily full-time. The participation rate for those 55 and over has risen from 23.8 per cent in 1996 to 37.9 per cent in 2019, but still, it is less than half the 87.3 per cent rate for Canadians 25-54. Labour market obstacles to the aspirations of older people should be examined, including inflexibility of pension and work arrangements.

Canada's business investment is weak with per worker spending on new capital in Canada lower than the average figure among reporting countries in the OECD (Robson, 2019). The Canadian context therefore demands that all sources of growth be examined: labour force, capital, and productivity.

Chart 7: Percentage Change from the 1990 Levels of per Capita and per Dollar GDP Emissions in Canada, 1990-2019



Source: Environment and Climate Change Canada (2021)

Concern over income inequality has grown in recent years in Canada and improving income distribution is a major focus of the current government. So too should it be a focus of an institute. Interestingly, the concern with inequality has coincided with rough stability in the key measures as noted earlier (Chart 4). Nonetheless, international comparisons show there are grounds for improvement. Using the Gini coefficient to measure income inequality, of the 37 countries analyzed by the OECD, Canada is close to the middle with 17 countries having more equal distributions and 19 worse (Chart 5). Canada is also in the middle of the poverty rankings with 20 countries having lower poverty and 15 higher (Chart 6). Canada should aspire for better.

Concern over income inequality often focuses upon re-distributing a given amount of income. An Institute could certainly look into this. But as well it should examine how growth and income are created. If a more representational group of Canadians were involved in the generation of growth and income, there would be less need for re-distribution. In a common vernacular, this is growing the pie rather than slicing it differently. But it is growing the pie from all dimensions.

An Institute could take a broader focus on inequality than simply income. Inequality can be found in many facets of life including access and affordability of health services, educational opportunities, legal services, financial advice, broadband, access to affordable housing and safety of neighbourhoods.

The Government of Canada has targeted net zero emissions by 2050. The environmental objective should not and must not compromise economic growth or, more generally, the well-being of Canadians. And it need not. But strategies will need to be set out to ensure this result. The focus must be on reducing the emissions intensity of GDP. The progress made since the late 1990s (Chart 7) must accelerate. This will certainly entail the development and absorption of new technologies. It will involve changes in production processes. It will likely involve shifts in resources across sectors and firms with substantial implications for workers.

Fitting the Canadian Context on Governance

Of the 10 pro-productivity institutions analyzed by Dougherty and Renda, four are housed at the centre of government (European Political Strategy Centre, France Strategie, Mexican Productivity Commission and U.S. Council of Economic Advisors) and six are independent. Of the independents, four report to the Prime Minister and two to Parliament. As the Economic Council of Canada, existing from 1963 to 1992, had some similarities to what is proposed here for an Equitable Growth Institute, it is worth noting it reported to the Prime Minister of Canada but had a Board of Directors drawn from a variety of backgrounds.

The governance of an Equitable Growth Institute in Canada must also fit the Canadian context. It should be an agency of the federal government. It would only be effective if the government recognizes there is an economic problem and is committed to finding solutions. That would require some foresight because the benefits tend to flow over a long period, whereas controversy can arise in the nearer term. For example, such bodies tend to recommend more competition and better regulation but those with vested interests in protected markets resist.

An Institute must have sufficient independence to challenge the status quo without the government feeling the need to be defensive. But it must be sufficiently connected to government that it has internal champions and is taken seriously. Yet even with considerable independence, a reporting structure would be required. Possibilities for reporting include the Prime Minister, the Minister of Finance, Parliament, or a Board of Directors established by the Government. Or, as in the case of the Economic Council of Canada, it could have dual reporting such as to the Prime Minister and a Board.

A particular feature of the Canadian context is the large importance of provinces and territories in the Canadian economy and policy. They should be involved, too. Formal representation of provincial/territorial governments may make the governance unwieldly, but there could be representation on a Board by individuals representing provincial/territorial perspectives. There could also be an advisory body to the institute with members connected to the other levels of government as well as business, labour and other stakeholders, including those dedicated to equity and sustainability of growth. The advisory body could also have direct discussions with the government.

Fitting the Canadian Context on Structure

The Canadian Equitable Growth Institute should be headed by someone with credibility in economic and policy matters. There should be an internal research staff, but it should also connect and foster existing research networks and create new ones where needed. Such connections should include other government entities including the recently established Future Skills Council, the Labour Market Information

Council and the Canadian Institute for Climate Choices.

An Equitable Growth Institute Must Delve into All Corners of the Economy and Policy

The Institute must have the authority and capacity to delve into all aspects of the economy and the policies that influence it. There was a time when much of the attention to economic growth and productivity in particular focused on "macroeconomic factors and policies". In the 1980s and 1990s that made sense in the Canadian context because macroeconomic policies were growth inhibiting with high government debt, high marginal tax rates, high tariff barriers and high inflation, to mention just some of the weaknesses. But many of these policy deficiencies were addressed at least in part, yet productivity growth did not improve.

That is not to suggest it was not worthwhile making the policy improvements. No doubt things would have been worse had policy remained on its prior course. But the record does suggest other factors have to be looked at. Analysis must reach into sectoral detail. Many sectors have productivity even lower than the 70 per cent average of that in the United States. At the other extreme, we have a number of firms that are world class, but few industries at the global productivity frontier. A thorough sectoral review of productivity levels relative to U.S. counterparts has not been done in almost two decades (Rao, Tang and Wang, 2004). Going a step further, the behavior of firms must be studied and how that is influenced by policies, both macroeconomic and microeconomic such as regulation and legal framework. Drummond (2011) provides a personal and somewhat broader account of this journey from the macro to more micro foundations of economic growth.

Internationally there is also some redirection happening in productivity research. To a degree the catalyst is observations of the failure of productivity to converge more across countries and the striking and persistent productivity gaps across sectors and across firms within sectors. This has led the World Bank to label some of its recent work "the second wave of productivity research". The approach is based on firm-level data disaggregating productivity into gains within firms, across firms through resource allocation and through market entry and exit. Drummond (2020) provides an analysis of this approach.

Fortunately, in Canada firm-level data have recently become more available with growing capacity to link to other data bases. Firm-level data along with detailed industry data could be fertile ground for an Equitable Growth Institute and take it into the world of regulation, competition policy, and intellectual property rights. It could take the Institute into investigating what is often called the "Valley of Death" in firm growth in Canada. This refers to the observation that firms are created at a fair clip in Canada, they tend to grow fairly rapidly at first, but then they stall or sell out once reaching a modest size. This is anti-growth and anti-productivity as productivity tends to be higher with larger firms.

An Institute should study who benefits from productivity gains. It was conventionally thought that productivity growth was fairly fully reflected in real wages. However, the link has come into question, not only in Canada, but in many countries, over recent decades as growth from productivity appears to largely accrue to higher-income individuals. For the United States, Mishel and Bivens (2021) identify excessive unemployment, eroded collective bargaining, and corporate globalization as factors that explain why median wages have not kept pace with productivity growth. Research should determine if such factors, or others, are at play in Canada.

An Equitable Growth Institute Should Address Some Big Questions

There are many big questions in the areas of economic growth, its distribution and its environmental effects. We address but three here.[3]

First, should Canada move beyond a fairly singular focus on Gross Domestic Product (GDP) as the metric of the economy? There is an international movement questioning how GDP represents an economy as it does not fully capture well-being or social welfare. Upon research, the Institute could recommend modifications within the existing structure, such as incorporating shadow prices of "free" goods and prices of difficult-to-measure products, or satellite accounts that connect specific economic, social and welfare domains such as health, human capital or the environment to the core GDP concepts.

Or the Institute could play a broader role in advancing the federal government's interest in a Quality of Life Index. In December 2019, the Minister of Middle Class Prosperity and Associate Minister of Finance was tasked with better integrating quality of life measurements into decision-making and budgeting. Since then, Finance Canada has done consultations and research leading to a report (Finance Canada, 2021b). The architecture of the index includes health, prosperity, society, environment and good governance, all viewed through the lenses of fairness and inclusion and sustainability and resilience. The Institute could help bring the Quality of Life Index into prime time. It could advise on what to measure and how. It could be the body to publish regular reports, thus providing a more objective perspective than might be the case as a government publication. It could draw together inputs from outside government, including academic researchers, think tanks and others. It could help formulate objectives for a higher quality of life for Canadians and recommends means to achieve that.

Second, the Institute could examine a conventional view that there is a trade-off between a strong economy and equity. In this view, measures to reduce inequality such as tax and transfer programs to redistribute income, reduce economic growth through channels such as work disincentive effects. But counter arguments can be made whereby reduced inequality could enhance economic growth and over time reduce fiscal burdens. For example, a more equal income distribution could improve access to education and training for those in the bottom half of the income distribu-

3 For a more comprehensive discussion of an equitable growth agenda for Canada, see Sharpe (2021).

tion.

Third, the Institute could look at the commonly expressed view that there is a trade-off between a strong economy and sound environment. The key is achieving smart or clean growth and facilitating adjustments throughout the economy.

An Equitable Growth Institute is Key to Advancing Canada's Goals on the Economy, Inclusiveness and Environment

Canada has a strong research community in government, academia and think tanks. This community could no doubt continue playing a valuable role in advancing Canada's interests. But the research and researchers tend to concentrate on particular pieces of the puzzle whereas the issues are broad and cross-cutting. An entity charged with taking a broad perspective and bringing together and facilitating efforts of others would be a valuable addition to what is in place now.

A Modest Cost for a Large, Potential Gain

There would be some cost associated with establishing an Institute, but the bar seems low for realizing a net gain. Raising the rate of productivity growth just 0.1 percentage points a year over the next 10 years, leading to an increase in economic growth from 1.5 per cent to 1.6 per cent, would boost the level of output in 2030 by $23 billion and the cumulative output over the decade by $121 billion. Between 30 per cent and 40 per cent of that gain would flow to the total government sector through existing tax provisions.

Those revenues are desperately needed by Canadian governments given the battering their fiscal positions have taken because of COVID-19 as well as future pressures on health care and pensions from the aging population.

Conclusion

The federal government could announce in short order its intent to establish a Canadian Equitable Growth Institute and begin consultations immediately thereafter.

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Putting Together the Pieces of the Productivity Puzzle: Review Article of *Productivity Perspectives* and *Productivity and the Pandemic*

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Abstract

The productivity puzzle in the UK may have taken a turn with the arrival of the COVID-19 crisis although we do not know at this point whether it will be for the better or the worse. The two edited volumes discussed in this review article are distinguished by the first being produced just before the pandemic, and the second in the midst of it. Together, the volumes address a broad range of economic, social and policy issues related to the productivity puzzle in the UK, with a strong focus on organization, management, entrepreneurship, innovation and skills. Beyond the firm there is much emphasis on inequality between firms, people and especially regions. There is also a strong plea for a system-based approach to policy making for productivity. On the whole the contributors take a cautious approach on how much the pandemic will change productivity performance in the medium-term, but they argue strongly in favour of active policy intervention to prevent damage and create better conditions for a sustained productivity revival.

The global slowdown in productivity growth in the past decade has brought productivity back at the forefront of the debate on economic growth. Perhaps nowhere else is this more the case than in the United Kingdom. Over the past decade we have seen an explosion in research on the UK productivity puzzle.[2] The two edited volumes discussed in this review article are examples of this heightened interest in productivity issues in the UK. The first volume *Productivity Perspectives* was published in

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2 For some broad overviews of the UK productivity puzzle, see Haldane (2018), Mason, G, M. O'Mahony and R. Riley (2018), Riley, R., Ana Rincon-Aznar and Lea Samek (2018), Zymek and Jones (2020), van Ark and Venables (2020) and Goldin *et al.* (2021).

2020 by Edward Elgar and edited by Philip McCann from the University of Sheffield and Tim Varley from Oxford Brookes University. The second volume, *Productivity and the Pandemic: Challenges and Insights from COVID-19* was published in 2021 also by Edward Elgar and edited by the same two individuals. The volumes are a culmination of a broad range of perspectives on the productivity puzzle brought together by the Productivity Insights Network (PIN) between 2018 and 2020. The network is an initiative funded by the Economic and Social Research Council (ESRC) in the UK which was created to initiate, facilitate and encourage cross-disciplinary research dialogues to address the productivity puzzle.[3] PIN has been led by professors Philip McCann and Tim Vorley from the University of Sheffield Management School, the editors of the volumes are widely recognized experts of regional economic development.[4] Unsurprisingly regional disparity within the UK is therefore one of the perspectives which is widely addressed in both volumes.[5]

The two volumes, which consist of 37 articles (including the two introductory articles) written by 55 authors mostly from business schools across the UK both bring together the existing stock of knowledge and report on new research. The insights from PIN are already making an impact in determining the future research agenda on productivity in the UK, as it has inspired the agenda of The Productivity Institute (van Ark and Venables, 2020) and other new research endeavours. The insights will also have a significant impact on the UK policy agenda which focuses on the post COVID-19 economic recovery, the levelling up of disadvantaged regions across the nation, and the government's intentions to revive the economy in the post-Brexit era to build a new global Britain.

While the two volumes have a primarily academic focus on what is called the "productivity puzzle" in the UK, the contributions are of great interest for a wider audience beyond academia. First, most articles are written in a very accessible manner. There are very few articles with complex mathematics or very data-heavy analysis. Second, even though the contributions are primarily focused on the UK situation, there are useful internationally comparative insights and important learnings for the productivity agenda in other countries.

The main challenge for any reader who wants to go through these volumes from cover to cover is that one needs to allow a good deal of time and focus for some dense reading of about 650 pages. For this reviewer, it's been like drinking from a fire hose. The two collections provide a treasure of hypotheses on the productivity puzzle and there are literally hundreds of references to relevant sources. To some extent this outcome is the nature of the beast. In

3 For an overview of PIN's contributors and published work see: https://productivityinsightsnetwork.co.uk/.

4 In 2021, Tim Vorley moved from the University of Sheffield to Oxford Brookes University, where he is Pro Vice-Chancellor and Dean of the Business School.

5 For earlier work by one of the editors on UK regional disparities, see McCann (2016).

many respects the UK productivity slowdown since the 2008 global financial crisis is like a death by a thousand cuts or, to stay with the theme of the puzzle, a bag full of jigsaw pieces.[6] To be fair, innovation and management deficiencies, skills shortages and mismatches, failing institutions and persistent and (on some counts) rising regional disparities in productivity performance are leading themes.[7] But even after absorbing the excellent introductions by the editors to both volumes, the reader is still left with the notion that while recognizing there is surely no silver bullet to resolve the productivity puzzle, the productivity agenda is also in desperate need of a comprehensive policy approach with clear, consistent choices, and one that requires political commitment for the long term.

In the remainder of this review article, I will first provide some guidance to the reader on where to find what in both volumes. I will then proceed by organizing some of the key insights from the 37 articles (including the two introductory articles) into five main buckets: (1) organizations; management; entrepreneurship and innovation; (2) skills; labour markets and well-being; (3) regional disparities; (4) policy and institutions; and (5) the impact of COVID-19. Finally, I will make a modest attempt in the final section on what the two volumes provide in terms of pointing the way forward for future research and policy.

Structure of the Two Volumes

The first volume, *Productivity Perspectives*, contains 16 articles contributed by 21 authors.[8] In the introductory chapter, the editors position the productivity slowdown in the light of the other big story of the early 21st century, namely rising inequality. They argue that economic growth and development may have reached a point beyond which the historical positive relationship between productivity and inequality has weakened. More specifically, societal benefits from productivity growth, for example in terms of broad-based gains in living standards and well-being, may have lessened because of factors such as a decline in knowledge spillovers and a slower (geographical) diffusion of knowledge. This kind of partitioning has raised inequities between firms, individuals and people over the past two decades.

Many of the chapters in first volume pick up on the topic of productivity and inequality by addressing who has access to and benefits from (domestic and foreign) investment, skill creation and innovation. Several chapters point at difficulties in ac-

6 The timing of the start of the productivity slowdown has still not been exactly sorted out. While the contributors in this volume treat the 2008 global financial crisis as the critical marking point, it has been suggested elsewhere that a statistical break in the UK's productivity path should be put in 2007, that is before the global financial crisis began (Fernald and Inklaar, 2020). This implies that while the financial crisis may no doubt have contributed to the severity of the slowdown, many of the seeds for a productivity slowdown were likely in place well before then.

7 Evidence suggests that the gap in output per hour between London and the rest of the UK has slightly declined since 2008, in particular because of a disproportional rise in working hours in less productive sectors in London. However, productivity differentials within the nine statistical regions in England, as well as in Northern Ireland, Scotland and Wales seem to have increased (Zymek and Jones, 2020).

8 The table of contents is available at https://www.e-elgar.com/shop/usd/productivity-perspectives-9781788978811.html

quiring the right skills and raise concerns about the distributional effects from increased labour market flexibility and new contractual and non-contractual arrangements between employers and employees. The last three chapters also address policy challenges related to equity including the siloed nature and geographical fragmentation of policy responses in the UK.

Shortly after the completion of the first volume, the world was hit by the COVID-19 pandemic causing one of the largest economic shocks of the post WWII period, and causing the largest decline in GDP (9.9 per cent) since the Great Frost in 1709. The PIN project courageously took up the challenge to put together a second volume, *Productivity and the Pandemic: Challenges and Insights from COVID-19*, in which 46 contributors, including 12 authors who also contributed to the first volume, produced 21 articles addressing the implications of the pandemic for productivity in the short- and medium-term.[9]

The contributions to the second volume were mostly written during the summer of 2020, when the first wave of COVID-19 infections was behind us but with the second and third wave still coming. At that point in time it was obviously difficult for authors to go far beyond describing the situation at that point and speculate about the possible impacts on productivity during the post-pandemic period. In the knowledge of where we are today, almost one year later, it seems most authors were correct in building on the insights from the pre-pandemic productivity slowdown as many factors (e.g. labour and skills shortages, increased disparity in the benefits from productivity) have returned in full force or even more strongly since the economy has begun to open up. Most contributors have been cautious in not overstating the upsides for productivity coming out of the pandemic ("never waste a good crisis") and have been adamant about the massive policy challenges to mitigate negative effects from the crisis and create better conditions for a productivity revival in the longer term.

Many chapters in the second volume address the implications of COVID-19 building on the analysis in the first volume, including the impacts on management, innovation and entrepreneurship. There are also new spotlights directly related to the effects of the crisis, such as online consumption, mental health issues, housing, and macroeconomic demand and supply effects. The direct implications of these development for productivity performance are sometimes harder to detect than was the case in the first volume. Some chapters in the second volume explicitly deal with the role uncertainty (e.g. Sena and Bhaumik, 2021; and Ernst, 2021) and resilience (Cook and Vorley, 2021) for productivity in the medium- to long-term.

Next, I provide an overview of five key topic areas that are returning in the volumes.

9 The table of contents is available at https://www.e-elgar.com/shop/usd/productivity-and-the-pandemic-978 1800374591.html.

Organizations, Management, Entrepreneurship and Innovation

As the majority of the contributors to both volumes are academics from UK business schools, it comes as no surprise that there is much focus on the internal processes within organizations and the impact of business investment, finance, management and innovation on firm productivity. As many of the authors also focus on regional performance and inequalities, there is a disproportionate amount of attention to micro-businesses and small and medium sized enterprises (SMEs), which dominate the business demographies in the most disadvantaged regions.

Several chapters address the weak productivity record of small firms in the UK. For example, Harris (2020) points to the decline in total factor productivity (TFP) growth rates in small firms, especially in the distributive and hospitality services. Henley (2020) discusses the challenges with regard to absorptive capacity in micro-enterprises, which refers to the notion that firms need to build capabilities to translate knowledge into innovation, and Mason (2020) reviews the scale-up challenges of SMEs and the lack of high growth firms. Indeed, the UK has seen a rapid increase rise in self-employment from 8 per cent of the workforce in 1980 to 15 per cent in 2015. While some of that increase includes gig-economy workers and other employee transitions to contract workers, 75 per cent of the UK self-employed represent business owners rather than freelancers or subcontractors (Henley, 2020). At the same time, the UK lags behind most other advanced OECD economies in creating scale-up companies.

On innovation, Huggins and Izushi (2020) build on the theme of absorptive capacity by arguing for a stronger connection between the theory of innovation and productivity, based on endogenous models of economic growth, and innovation management models, based on behavioural and institutional-based conceptual frameworks. Innovation behaviours are in part determined by the formal and informal institutions but also interact with cultural, psychological and human agency characteristics. For example, the authors argue that "the concentration of large-scale coal-based industries in regions has left a lasting psychological imprint. The selective out-migration of more optimistic and resilient individuals seeking new economic opportunities results in an indigenous population in the home region lacking in its entrepreneurial spirit and innovative capabilities." (Huggins and Izushi, 2020:113).

Lack of finance for growth, partly from banks but particularly from venture capital funds, is often pointed to as a key inhibitor for scaling up small firms in the UK. In Chapter 7 in Volume I, Mason points to specific constraints in the UK, such as the large amount of time venture capital firms spend on raising capital rather than working with their investee companies, the lack of funding for multiple rounds of investment, and deficiencies in operation and entrepreneurial experience in venture capital firms. The latter also seems to play out in regional disparities, providing a significant disadvantage to innovative SMEs outside London and the southeast of England.

Finally, there is an extensive literature that weak management capabilities are one of the causes of the long-tail of less productive firms in the UK.[10] Henley (2020) reports on research which finds that entrepreneurial firms, i.e. those that are classified as being less than 7 years old, employing fewer than 100 people and which are also new market entrants, are no more productive than non-entrepreneurial firms (which are classified on the converse criteria). Detailed interventionist studies show that better management of human resources and organizational changes have raised productivity in entrepreneurial firms. Mason (2020) argues that top management teams (TMTs) are key to scaling up of small firms, but are often not put in place because of cost considerations and short-termism.

While the strong focus on micro-businesses and SMEs in these chapters is aligned with the notion of long tail of low productivity firms in the UK, I think the volumes miss out on discussing the disproportionate contribution that large firms make to productivity. In one respect, despite the impact of the long tail on aggregate productivity, much can be made up for by better productivity performance of the larger firms. The presence of large productive firms can help to integrate smaller firms in regional, national and global supply chains, and invest in capabilities or business development at the tail end.

Skills, Labour Market and Well-being

Four chapters in the first volume explicitly address the challenges regarding the contribution of human capital to productivity. (Abreu, 2020) provides an excellent overview of the challenges from the level of early childhood education, primary and secondary schooling, higher education to adult skills. On the performance of the first three categories the picture that emerges is rather consistent in that, on average, the UK is not far away from the OECD average, but the disparities in terms of access and performance in education are relatively large between socio-economic groups and regions in the UK. There is mounting evidence that underperformance across large swaths of the population even at the level of early childhood and primarily schooling can seriously constrain the productivity performance of individuals and the organizations they work in at a later stage in life. The education problem in the UK is exacerbated by the widely documented underperformance in adult skills and further education (FE), where it underperforms more broadly compared to other countries. A lack of attention for non-cognitive skills and underfunding outside the formal education system are some of the issues which need to be urgently addressed.

Lisenkova (2020) discusses the demographic challenges for the labour market related to aging of the workforce, and Newsome and Vorley (2020) provide a broad overview of labour market issues, including new workplace arrangements, labour market flexibility, and other changes in employment relationships. Both chapters point to major data gaps, such as the scarcity

10 See, for example, Bloom and Van Reenen (2007) and Haldane (2017).

of employer-employee datasets and data on non-standard work in the UK, which need to be addressed before more definitive statements on the impact of aging and workplace settings on productivity can be made. Both chapters also point at the need for better data on skill requirements by employers, in order to reduce mismatched in skill provisions.

Although touched upon in various contributions, the article by McSorley (2020) is the only chapter in the first volume that explicitly addresses the topic of productivity and well-being. The chapter describes how the link between productivity and wages may not have fully delinked in the UK but has certainly weakened. In other words, productivity growth may be necessary for raising wages but it does not seem to be sufficient to sustain living standards widely across the economy. Job quality and employee well-being are important factors affecting on living standards and potentially provide positive incentives to workers to raise their productivity. This also brings us back to a decades-old debate on the causality between productivity on the one hand and well-being and living standards on the other. While research at the macroeconomic level mostly focuses on the causality running from productivity to wages, in much of the innovation, sociology and human resources literature the interest is primarily in the reverse causality.[11] McSorley also argues that productivity needs to be a key component of an inclusive growth agenda, and suggests that demand-side policies as well as the need for digital and other technological diffusion to support rather than undermine inclusive growth are key elements for securing that link better.

Regional Disparities

On all dimensions discussed so far the high degree of regional disparities in the UK has been looming in the background. McCann's article in the first volume (McCann, 2020) following the introduction summarizes the peculiar pattern of geographical inequality in the UK, which is described in much more detail in his earlier work (McCann, 2016). In sum, the UK's geographical inequalities are not so much the result of the well-known differences in productivity performance between agglomerations and smaller towns and rural areas. Instead there is a true regional disparity in the UK whereby London and the Southeast not only outperforms all other UK regions but also most other agglomerations in OECD countries. In contrast, most other regions in the UK (including many cities) systematically underperform relative to London and the Southeast as well as to comparable regions in terms of population and level of economic activity in other countries. In fact, many UK regions have levels of productivity more comparable with regions in Central and Eastern Europe than regions nearer by in Northern and Western Europe.

The contributions by Gardiner and Lewney (2020) in the first volume and Gardiner, Lewney and Martin (2021) in the second volume dive deeper into the differ-

11 See also, for example, OECD (2018), Isham, Mair and Jackson (2020).

ences in productivity growth between types of cities and towns as well as rural areas. While largely confirming the broad pattern of the London and Southeast productivity advantage, certainly in terms of productivity levels, there are also substantial differences in growth performance between cities and towns across the UK. For example, some cities which are smaller in size than the UK's eleven core cities outside London performed as well on productivity growth as London did over the past decade. And while the core cities were on average weaker in growth terms than the average for smaller cities, they clearly outperformed small towns and villages in the rural areas. Within regions there are still large differences between localities though often related to specific well-performing hotspots with a small number of star companies (or even only one) with limited spillovers to other firms in the region. This again points to the challenges of startups and SMEs across the UK discussed above.

Whatever the precise reason for the regional disparities, the persistent nature of these disparities creates a significant policy challenge, referred to as the "regional innovation paradox". This paradox points to the inability of underperforming regions to effectively utilise the spending made available for innovation and entrepreneurship because they miss the essential capabilities to absorb the new investments. This observation has important implications for the levelling-up agenda in the UK aimed at improving the fortunes of disadvantaged regions. Large fiscal transfers, moving government offices out of London, or building high speed rail services from London to the North may help, but do not in themselves create the absorptive capacity for regions to regenerate growth.

At the end of the day, the question arises is what is required to rebalance the economy. Gardiner and Lewney (2020) argue we need a better understanding of how underutilized resources can be productively used, what the innovation capabilities of different sector activities are, and how to identify the skill requirements for rebalancing. But even before that come other important questions such as what rebalancing should actually achieve, whether the levels of inequality are in fact efficient or the result of market or policy failures , and how economic efficiency relates what is socially or politically acceptable.[12]

COVID-19

Enter COVID-19. In recent months, the impacts of the pandemic on productivity have been widely discussed.[13] As mentioned above, the contributions in the second volume were written in the summer of 2020, and while most insights on future impacts on productivity were still speculative the authors wisely took a cautious approach.

Some of the chapters in the second volume build on insights from the first volume, outlining the short term disruptions of the pandemic against the long term underlying trends. For example, Henley, Vor-

12 See, for example, Floerkemeier, Spatafora, and Venables (2021) for a discussion.

13 See, for example, Bloom *et al.* (2020) and Riom and Valero (2021).

ley and Gherhes (2021) point at the risk of the long tail of unproductive firms being most affected by government restrictions and more dependent on the business support programmes put in place during the pandemic, with the risk that more zombie-type firms will continue to exist in this segment of firm size. Mason and Hruskova (2021) point at the damage the pandemic does to knowledge sharing among firms, and Mason (2021) provides an interesting complementary argument to his analysis of business financing in the first volume (Mason, 2020), namely that angel investors backed out relatively early in the pandemic, providing another disadvantage to SMEs relative to larger firms.

Other contributors directly address the impact of COVID-19 on productivity. For example, Mills, Whittle, and Brown (2021) on the shift to online consumption uses insights from behavioural economics to identify longer-term impacts of the acceleration in technology and the use of data-driven business models on consumer's shopping behaviour. While disruptive in terms of its impacts on firms and workers, the exact implications for productivity will remain unclear until consumers will have adapted to a new "equilibrium" on on-line versus off-line consumption. Huggins and Thompson (2021) argue that while the concentration of innovation activities in cities will not evaporate because of the pandemic, the drop-off in commuting and the declining need for face-to-face interaction might bring about behavioural changes that could become permanent and facilitate spatially distributed innovation systems.

Even with the possibility of opportunities for productivity improvements emerging from the crisis, most contributors in the second volume point at the need for active policy intervention to not only realize the opportunities but also to limit the damage the pandemic can do to productivity and prosperity. For example, the fragile link between productivity and well-being link described above has become more exposed during the pandemic, requiring strong policy responses. Green (2021) describes how the pandemic caused educational disruptions and negatively impacted on skills formation. Kopaskar (2021) provides an account of the pandemic's impact on mental health and economic insecurity. Findlay, Lindsay, and Roy (2021) discuss employee experiences and engagement, and Jones (2021) looks at the rising mismatches in the job market during the pandemic. All these factors point at the possibility of substantial scarring effects on the labour market and rising inequalities because of the pandemic. Those effects are likely to be only reflected in the productivity numbers with a significant delay.

Most importantly, the second volume brings up the impact of uncertainty and the need for resilience in times of crisis. Harris (2021) points at the greater vulnerability of global supply chains to shocks and the possible incentives for automation to reduce uncertainty and for reshoring to strengthen resilience. Sena and Bhaumik (2021) look at firms' supply chain decisions in times of uncertainty, expressing concerns about detrimental effects from finance constraints for companies to change course. They call for government to align their fiscal policies at national, regional and local level with the requirements of industrial policies in times of uncertainty.

Ernst (2021) explicitly questions the emphasis by businesses and policy makers on static efficiency gains and cost savings in past decades, supported by a combination of technological change, deregulation and globalization. This has overexposed economies to economic shocks causing a potential threat to long-term sustained growth in productivity. Ernst argues for reset of the policy framework to balance efficiency gains and resilience needs by adopting a longer-term view, creating redundancies and buffers to deal with crises, focusing more on the provision of public goods, raising agility in bringing technological solutions to bear (as happened, for example, in health care technology during the crisis), and improving communication and expectation management.

Cook and Vorley (2021) also point at the need for greater resilience in innovation policy and argue for a broader set of criteria in assessing the effectiveness of innovation policies including a widening of objectives in terms of societal, environmental and health related targets and a greater emphasis on diffusion and adoption of innovations.

Policy and Institutions

Throughout the two volumes the importance of policy for productivity is prominent. Given the diversity of topics covered, it is obvious that the policy recommendations also refer to a large number of policy domains touching on productivity. Those include education and training, innovation, fiscal policy, housing, transportation and infrastructure, health care, energy, agriculture, and regulations in labour, product and capital markets.

Many of the policy issues come together in the final three chapters of the first volume, where the preference for a systems approach to policy is a common theme. Vorley and Nelles (2020:278) argue that "productivity is . . . . about more than the coordination of policy areas, in that it is about the capacity to respond to dynamic economic challenges that change over time and in relation to the actions of other individuals, industries and economies". A systems approach to policy allows for a focus on intersections and interdependencies of policy domains rather than a siloed approach. The arrival of COVID-19 has provided a push to this change, as siloed policies have turned out to be useless in times of crisis as the two Vorley and Nelles discuss in their contribution in the second volume together with Brown (2021).

Cook, Hardy and Sprackling (2020) provide a very useful review on how key policy domains related to productivity, in particular business support, innovation and skills, have evolved since the late 1990s. They describe the five driver framework (investment, innovation, skills, enterprise and competition) for productivity introduced under the Labour government in the 1990s and early 2000s, and the creation of nine Regional Development Agencies (RDAs) to advance the growth and productivity agenda at devolved nation and regional level. The Conservative-Liberal Democrats government abandoned the RDAs in the late 2000s and instead set up 39 Local Enterprise Partnerships (LEPs). The LEPs allowed for more specific place-focused strategies, supporting a more targeted approach of business support for growth companies with scale-up potential and creating more room for mentoring and peer-to-peer networks. But it also caused a greater centralization of key budgets and oversight by the central government.

The authors argue that the goal of simplifying the plethora of policy tools for productivity growth has not really been achieve as the agenda has in fact become more complex. Policy devolution has in part transferred decision making to regional and local levels, but also caused horizontal and vertical fragmentation across policy domains and between different levels of government respectively. Underfunding, especially during the period of macroeconomic austerity after the global financial crisis has made it more difficult to implement adequate policies at the level of LEPs.

The final chapter in the first volume by Dymski (2020) provides an interesting comparison of the UK with the policy environment in California (a state of comparable size with the UK economy). Any comparison of countries and regions with vastly different economic, social and political structures runs the risk of oversimplifying. However, the chapter does clearly show the risks of the top-down and overly centralized approach to science and technology in the UK. In California, the allocation of funds for science and technology is largely left to the business community in collaboration with a generally well-funded public post-secondary education system which collaborates at the local level and is networked nationally and internationally. The article also points to underfunding of regional and local policy initiatives risking an effective devolution of policies for policies. But not all is sunshine in California, as Dimsky mentions the failure of California's policy mechanisms to deal with the large degree on economic inequalities in the state, flying in the face of the concept of inclusive productivity growth discussed above.

How From Here To There?

In this final section, I aim to sketch the key elements of the future domains for research and policy on productivity together, assuming the two are deeply intertwined. In doing so I rely heavily on the key insights from the two volumes above. However, while the volumes leave few stones unturned, there are still some key elements of the agenda that have been underexposed. Finally, I will also rely on the current research agenda of The Productivity Institute (Van Ark and Venables, 2020), which has been inspired to quite some extent by the work of the Productivity Insights Network.

Technology, Innovation and Organization

The first main area of focus for the future productivity agenda can be called technology, innovation and organization. I have explicitly added the word "technology" which is not very extensively addressed in the two volumes. Most contributors put the emphasis on organizational factors to support the adoption and absorption of technology. While this seems to be the correct focus, especially in the light of creating a more inclusive productivity agenda, the key role of science and technology underlying productivity growth should not be underplayed, in particular not in the case of data sciences and other digital technology applications.

Related to this, both volumes focused extensively on the role of SMEs and microbusinesses. This may leave the impression that the productivity puzzle is mostly or even exclusively about the long tail of smaller and less productive companies. While R&D spending is heavily concentrated in large incumbent firms, the limited presence of spillovers through supply chains and integration in regional innovation ecosystems are important factors adding to the productivity puzzle in the UK.

Skills, Labour Markets and Inclusive Productivity Growth

The second main area of focus for the productivity agenda is skills, labour markets and inclusive productivity growth. The critical importance of skills, arising from general and vocational education as well as formal and informal programmes for adult skills, is well covered in both volumes. The potential scarring effects of the pandemic can have long-lasting effects on cohorts of the future workforce, and the policy agenda should also explicitly address those challenges for productivity effects in the longer-term. While flexible and other new types of work arrangements are explicitly covered in the chapter by Newsome and Vorley in the first volume (2020), they do not explicitly deal with the rising importance of gig economy jobs and other work arrangements linked to new technologies. The future productivity agenda should explicitly address how such new arrangements fit in with the need to raise worker engagement and increase their benefiting from productivity growth in material terms through wages as well as in less tangible ways through employee engagement and worker satisfaction. Finally, I have explicitly added the term "inclusive productivity growth" to this area of focus. Inclusivity is critical form the perspective of generating a broad sharing of the benefits of productivity growth. However, it relates as much to the wider access to the sources of productivity growth, includes education, health, housing, transportation, etc. (OECD, 2018).

Integrated Policies, Institutions and Governance

The third main area of attention in the productivity agenda focuses on integrated policies, institutions and governance. The systems approach, which is advocated by several contributors to the two volumes, is critical to integrate the horizontal and vertical elements of policies that are relevant to productivity. However, such approaches put a huge demand on the quality of policy making and the skill set of policy makers. Interdisciplinary thinking, a long-term focus, continuous learning, and willingness to experiment and to accept failures are just a few of the skills that are required. In addition, such characteristics are not only needed at the national policy level, but also at regional and local levels. There is also a risk of overengineering the policy environment, which could in turn lead to knee-jerk responses by (re)centralizing policy initiatives trying to reduce fragmentation and complexity. To balance those countervailing pressures between centralization and devolution, the research community needs to develop complementary interdisciplinary research approaches to provide policy makers with the critical evidence on which they can base their policies.

Spatial Performance in a Global Britain

The fourth area of focus in the productivity agenda is the spatial performance in a global Britain. The two volumes reviewed here are deeply embedded in the wide ranged regional disparities discussed in this review. Understanding the causes of persistent regional disparities and the unlocking of sources for productivity growth is a crucial piece of the agenda. However, regional performance should not be looked at purely in the national UK setting but also be understood in light of the rapidly changing international context. Although the introductory chapters to both volumes and the scene-setting article by McCann (2020) in the first volume are extremely useful, the volumes could have benefited from greater depth on the international context of the UK productivity puzzle.

The divisive nature of the political discourse at the time of writing their contributions, may have made authors wary to take on the productivity implications of Brexit. But the ambitions of the political agenda for a new Global Britain need to be scrutinised for its implications on productivity of frontier and laggard firms. For example, the consequences of a redirection of trade flows between Britain and its key trading partners in productivity need to be better understood. New technological alliances may also have important implications for the sectoral and spatial structure of productivity in the UK.

The comparative perspective on productivity performance between regions and nations also needs to extend to the industry level. While there are some references in both volumes to the impact of new trade relationships for productivity growth in the most exposed sectors, a more systematic analysis would be welcome. This work would not just be relevant to better understand whether exposed sectors will continue as key drivers of productivity and whether, for example, certain manufacturing industries, despite their small share in output (and even more so in employment) still matter disproportionally for stimulating productivity growth at the aggregate level. It would also be relevant to understand which type of industrial activities within regional and national supply chains or global value chains may add most to a productivity revival. The direct and indirect effects of foreign direct investment and the degree to which such investment strategies are technology-sourcing or technology-exploiting, as discussed by Harris (2020) in the first volume can also be addressed in this context.

Measurement of Productivity

The fifth area of focus is on Measurement of productivity and productivity-related matters, including aspects of inclusive productivity growth. The contribution by Sena (2020) in the first volume provides an outstanding review of definitional and measurement issues, including a very useful overview of 69 data sources from the Office of National Statistics and other data providers which are of relevance for productivity research. The author argues that these data sources provide great opportunities for improved measurement of productivity-related drivers at granular firm level, but calls for a significant intensification of efforts by the Office of National Statistics and the research community to step up efforts to link the various data sources and build longitudinal firm-level and household datasets by which employer and employee activities can be linked and followed over time.

Such matched and linked datasets will be essential for a better understanding of the geographical dynamics and the various elements of absorptive capacity within firms and regions. The call by Waind, Ritchie, and Bailey (2021). in the final contribution in the second volume shows the potential of how linked data from the Administrative Data Resources (ADR) have been used to provide critical and timely information on the effects of the pandemic on the economy and people's lives.[14] Official government data sources can be also be mapped on semi-public datasets such as the Decision Makers Panel at the Bank of England and a large range of private data sources in the area of labour markets and business statistics.[15]

A critical extension of the measurement agenda for productivity includes the measurement of factors relates to inclusive productivity growth. McSorley (2020) in the first volume calls for improved measures of social infrastructure, which could simply mean an extension of physical infrastructure supporting social objectives, such as health care, housing and education. More broadly, social infrastructure, could also measure the extent to which broad access to such social infrastructure is guaranteed. This would help to not only better understand the costs and benefits of social infrastructure in purely monetary terms but also in terms of its effect on well-being and living standards.

Climate Change and Net-Zero Emission Policies

Finally, one key element that is largely missing from this rich collection of work on productivity are the challenges from climate change and net-zero emission policies. So far there is surprisingly little discourse, let alone research, on the productivity implications of a net-zero agenda, and it is often assumed that in the long-term it might be beneficial. However, in the short- to medium-term it seems most likely that the resource-intensive transition from the highly productive and capital-intensive exploitation of fossil fuels to a non-fossil energy system will have negative effects on productivity growth. In addition, sectors that are heavily dependent on energy, such as basic goods industries but also the transportation sector will face high adjustment costs when switching to new energy, sources impacting productivity. The potential productivity gains from a green technologies are likely to come from mitigating the detrimental effects of climate change and, in the longer term, from productivity gains across the economy once clean technologies are scaled up and innovation from the circular economy are widely adopted. To conclude,

14 See www.adruk.org.

15 See https://decisionmakerpanel.co.uk/.

these two volumes from the Productivity Insight Network represent a major achievement in bringing together a broad range of insights related to the productivity puzzle. While many of the articles reflect the business school background of the contributors, it is hugely important to see their different perspectives from management, finance and innovation, as well as a good deal of economics, together in one place. The next step for the research agenda is to build a truly integrated research agenda which aims to answer the many relevant questions from an interdisciplinary perspective. Indeed, the systems approach applies as much to policy making as it does to research, and academia, business and policy makers will need to look at the key issues together. Only this way the thousand or so pieces of the productivity puzzle can be put together into a wholesome picture that could point the direction towards a new era of productivity growth.

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Productivity Measurement with Data Envelopment Analysis and Stochastic Frontier Analysis: A Review Article on *Measurement of Productivity and Efficiency: Theory and Practice*

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The backside blurbs on this voluminous volume entitled *Measurement of Productivity and Efficiency: Theory and Practice* by Robin C. Sickles and Valentin Zelenyuk (600 pages) and published by Cambridge University Press in 2019 are intimidating to any potential reviewer: "the most comprehensive book on production theory and the measurement of productivity", "an amazingly comprehensive survey of the field", "a complete and thorough introduction", "a comprehensive survey and creative extension", "this monumental book on theory and practice". Maybe this is why it took this journal so long to find a suitable reviewer. And even the present one is not an expert on all the topics covered in this book, if this were possible at all. Thus, to start with, I sincerely apologize for any bias, mistake, or oversight.

Productivity and efficiency are distinct, but related concepts. Productivity has to do with the relation between the quantities of inputs and outputs of an economic agent, the change of this relation over time, or the differences between this relation for comparable economic agents. A typical productivity measure is output quantity divided by input quantity. This sounds simple, but is not. "The" productivity, of an enterprise, an industry, or an economy, does not exist. There is a myriad of questions to answer before computation can start. What is the output concept: revenue (gross output) or (real) value added? Do we take into account all the inputs, resulting in so-called total factor productivity (TFP), or only, say, labor inputs, resulting in labour productivity? Then, except in the case of a single input and a single output, quantities must be aggregated; hence, one needs weights, probably prices, but from where?

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There is the choice of the proper accounting period. How does one account for underutilization of inputs or overproduction of outputs, peak- and off-peak production, seasonality? *Etcetera*.

Efficiency has to do with the relation between quantities of inputs and/or outputs of an agent relative to some benchmark. The benchmark could be another agent or some mean of agents. For such a comparison to make sense the agents of course must be comparable. For example, the efficiency of an enterprise could improve by producing the same output quantity with less inputs, or by producing more outputs from the same input quantity. Improving efficiency means improving productivity- *ceteris paribus*, since productivity can also improve without efficiency improvement, for instance by raising the scale of the operations of the enterprise. Thus productivity has more components than efficiency alone.

In the usual, neo-classical theories firms, or more aggregate economic entities, are assumed to act efficiently. In essence this implies that the determining component of a firm's productivity turns out to be the technology, understood in the broadest sense of the word, by which the operations of this and similar firms are governed. Productivity change then becomes (almost) identical to technological change, and the interest becomes focused on the drivers behind. In the book under review the central role is given back to efficiency and the many ways of measuring this in a given data situation. In the actual world *in*efficiency is everywhere!

The stage of the play is occupied by a certain number of so-called decision-making units (DMUs), which can be plants, establishments, industries, groups of industries, or economies, with or without a time dimension. The central place is given to the concept of technology, defined as the (temporal) set of all the feasible combinations of input quantities (contained in an N-dimensional vector x) and output quantities (contained in an M-dimensional vector y). All the DMUs are supposed to have access to this technology, which thus serves as the benchmark relative to which efficiency is defined.

Chapters 1 and 2 discuss all the basic theoretical concepts, assumptions, and properties: technology set, output set, input set, distance functions, returns to scale, scale elasticity. Then cost function, revenue function, and profit function.

Chapter 3 turns to the precise definition of efficiency. Several alternatives have been developed in the course of time. They all boil down to measuring the distance between the actual operations of a DMU, summarized in its (x,y) combination, and the frontier of the current technology set, which determines the best input-output combinations. As only quantities are involved, the inverse of this distance is called technical efficiency. The farther away from the frontier, the less efficient the DMU is. If instead of the (primal) technology frontier one of the dual representations (such as cost, revenue, or profit function) is chosen there results economic efficiency, as prices are involved. The gap between economic efficiency and technical efficiency, measured in ratio or difference form depending on the particular functional form of the distance measures involved, is called allocative efficiency.

Chapter 4 formally defines productivity change. Also here is some choice. Productivity change can be measured by means of the Solow residual, or by means of a member of the Moorsteen-Bjurek, Caves-Christensen-Diewert, or Malmquist-Luenburger families of indices. Their decompositions are discussed, as well as their properties. Noteworthy is that all these indices are intransitive; that is, productivity change from period 0 to period 1, times productivity change from period 1 to period 2, is generally unequal to productivity change from period 0 to period 2. The underlying reason for this is not difficult to understand. Any satisfactory measure of productivity change requires input and/or output prices for the aggregation of input and/or output quantities. Prices adequate for comparing period 1 to period 0 are usually different from prices adequate for comparing period 2 to period 1, and both sets of prices are usually different from prices adequate for comparing period 2 to period 0. All this can of course be formalized in neat mathematical impossibility theorems.

Usually practitioners are not only interested in the performance of this or that individual agent, but also in weighted or unweighted means of groups of agents. The topic of aggregation thus demands attention. Chapter 5 treats aggregate efficiency, scale elasticity, and (dual) productivity index. The basic assumption here is that all the DMUs in each time period face the same prices.

Theory is beautiful, and one can spend a lifetime in devising subtle generalizations, but for actual application a bit more detail is necessary. In particular, one needs a specification of the technologies involved. Chapter 6 reviews a large number of alternatives: functional forms for the production function (in case of single output, M=1), the output distance function, the cost function, the revenue function, and the profit function. Special attention is paid to so-called flexible functional forms; that is, functions that can provide second-order approximations to unknown target functions at specific points.

Still, this leaves us with the problem that parameters of the particular functional form one has selected must be known. Fortunately, for some functional forms and under the assumption of optimal behavior of the agent – thus, under full economic efficiency – productivity indices reduce to statistical indices, computable from observable prices and quantities. The Fisher index is a great example. This then leads us in the area of index number theory, a topic discussed in Chapter 7.

An alternative to maintaining all those assumptions is to estimate the unknown technologies directly from sample data. There are several approaches possible, one of them being Data Envelopment Analysis (DEA). The basic idea of DEA is relatively simple to understand. Given a sample of data points (x,y), it is natural to assume that each data point is a member of the current technology, defined as the set of all the feasible input-output combinations. For any data point (x,y) it is next assumed that all the points (x',y') with x' larger than or equal to x and y' smaller than or equal to y also belong to the technology set. The union of all those south-eastern data sets then constitutes an inner approximation of the unknown technology set, and connecting the outermost data points provides an envelopment of the sample data.

Under the acronym DEA a myriad of more or less sophisticated models has been developed. All these models are implemented by means of linear programming techniques. The most important, imposing constant or variable returns to scale, are explained and discussed in Chapter 8.

As any envelopment model provides an estimator of the true, but unknown, technology, there are statistical issues to discuss. This is done at length in Chapters 9 and 10, first focusing on individual efficiency scores, and next on aggregates and distributions. There is also an introduction to two-stage DEA, where DEA-based efficiency scores of individual agents are regressed on potentially explanatory variables.

Chapters 11-14 cover stochastic frontier analysis (SFA). The basic, canonical model states that (single) output of a DMU is equal to the outcome of a production function (of input variables) minus a (positive) stochastic term representing technical inefficiency plus a stochastic term representing random disturbance. It is clear that there are some choices to make here before estimation can take place: specification of the production function, and specification of the distributions of inefficiency and disturbance. Since its inception, in the 1970s, this idea has generated a tremendous literature, hard to keep up with by a single person. Thus any survey is probably a bit biased by the individual research interests of its author.

After a detailed discussion of the basic model in Chapter 11, the developments in the field of SFA are surveyed in the next chapters. Chapter 12 covers endogenous growth models, time-varying inefficiency, panel models, the incorporation of environmental factors, and how to distinguish between wanted and unwanted outputs. Chapter 13 continues the increasing sophistication with a discussion of latent class models, and the incorporation of spatial effects. This chapter concludes that "it is not at all clear … which method is the best and thus which method(s) should be viewed as the gold standard for panel efficiency analyses" (page 448). Chapter 14 discusses the endogeneity problem (caused by correlation between explanatory variables and stochastic factors) in the estimation of production functions and SFA models.

Chapter 15 introduces dynamics in DEA-based efficiency measurement and in SFA-based panel models. Think of convergence over time of the productivity of economies; or distinguishing between short-run and long-run inefficiency.

Chapter 16 is the final theoretical chapter. A number of remaining topics are discussed: How to impose theoretically required regularity conditions on estimated production, cost, or other functions? Can semi- or nonparametric methods help us? How to obtain a consensus model out of a number of competitors? Model averaging sounds great, but what weights to use?

Chapter 17 starts with a brief (two pages only) section on data measurement issues and then turns to papers from the 2016 World KLEMS Conference, as published in the Fall 2017 issue of this journal, the *International Productivity Monitor*. All these papers were circling around productivity, the topic of the book. Thus, one would expect a certain degree of cross-referencing. However, the conclusion that "there is not one reference given in this collection of papers to any studies in the literature on measuring productivity and efficiency by other leading productivity scholars whose contributions have been discussed at length in this book." sounds like a cry from over an abyss, from one group of scholars to another. By and large this corresponds to my own impression that researchers brought up in the neo-classical tradition of thinking about productivity usually do not even read stuff from researchers who dare to dispute their cherished articles of faith. Neither do they engage into a public discussion.

This is not just a matter of using different techniques by protagonists of the two camps. It has more the traits of an ideological difference. The typical neo-classical economist starts with a bunch of assumptions, *e.g.* that agents (enterprises, industries, economies) display optimizing behavior of some kind (such as revenue maximizing, cost minimizing, or profit maximizing). Protagonists of the other camp avoid assumptions as much as possible, behavioral assumptions above all, and try to let the data speak. Kwak (2018:146) relates the majority view to academic upbringing:

> "Economics 101, ..., assumes that firms always rationally maximize their profits. ... But anyone who has ever worked at a large company – or read *Dilbert*, for that matter – knows that corporations are not ruthlessly efficient profit maximization machines, but collections of fallible and often self-interested human beings."

An interesting thought experiment would be to give protagonists of the two camps access to the same data set. It is highly likely that at the end of the day they will be looking at the same table containing, say, growth percentages derived from annual Fisher-type TFP index numbers. The neo-classical economist considers these as measures of technological change, and is surprised about the strikingly irregular features of the time-series. The other economist just takes these outcomes at face value, as measures of real profit or profitability change, and starts looking for explanatory components: technological change, efficiency change, scale change, *etcetera*

Back to the book. Chapter 17 closes with a list of publicly available data sets and a list of software. Such an undertaking is always a bit tricky, as the material is never exhaustive – for example, Statistics Netherlands is missing in the list of data sets, or can easily exhibit bias – for example, by taking on board only software developed by or related to the authors.

This concludes my review of the contents of this book. There is much to praise in this book. The explanations of models and estimation procedures are generally very clear. Each chapter contains a number of exercises, which makes the book very suitable as material for (advanced) academic or professional courses. But also researchers will want to have this book on their desk for reference purposes. It provides a synthesis of and access to a large literature.

A negative point is that, except for the two pages mentioned above, the book does not contain a serious discussion of measurement issues; that is, all the issues that must be solved before some formal model can be applied. All the models are based on input quantities x and gross output quantities y (if $M > 1$) or real value added y (if M=1), as if those data are simply observable. Except in the most simple cases, however, quantities are not observable due to the sheer number of commodities involved. At the lowest level of aggregation one thus has to work with sums of quantities and nominal values. At higher aggregation levels quantities, as required by theory, are usually substituted by real values, that is, nominal values deflated by some more or less suitable price index; which means that there is some normalization and functional choice involved. Finally, real value added is not observable at all, but a construct, obtained by deflating revenue, deflating intermediate input cost, and subtracting the outcomes.

Especially the second part of the book shows the progress made over the last twenty years since the appearance of the standard SFA book by Kumbhakar and Lovell (2000). The increased sophistication of the SFA models and the accompanying estimation techniques is remarkable.

For the first part, especially Chapters 1-7, I am not so certain that there has been much progress. A global comparison with Balk (1998) reveals that theoretical differences are almost negligible. Notable is, however, that a number of topics are missing in the Sickles-Zelenyuk book, the most important being the use of so-called indirect models, where input cost is related to a target revenue instead of output quantities, or where revenue is related to a given input budget rather than input quantities. A new topic is the aggregation of DMUs in Chapter 5. Unfortunately, the treatment is restricted to DMUs operating without interaction or reallocation of resources between them. Extensions of the theory, as referenced in the concluding remarks of the chapter, only go to 2014.

A feature of the whole book is that all the models follow the (x,y)-format; that is, on the assumption that x covers all the inputs and y all the outputs of a DMU, only the measurement of *total* factor productivity is treated. There is hardly any explicit attention for labour productivity, other partial productivity concepts, or the relations between them. Also the concept of Consistency-in-Aggregation, important when working with index numbers and actual data, is not touched.

The authors must be praised for providing throughout the book so many references to the literature. When it comes to historically interesting sources many articles are qualified as "seminal". Based on having four or more lines in the Author Index, the giants in the field of productivity and efficiency measurement appear to be Erwin Diewert, Rolf Färe, Alois Kneip, Peter Schmidt, Robin Sickles, Leopold Simar, Paul Wilson, and Valentin Zelenyuk. I wonder whether in circles of neo-classical economists sufficient attention – more than lip-service – has been paid to their work. It is thus appropriate that for all this work a monument has now been erected.

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