UNIVERSITY OF CAMBRIDGE

Cambridge Industrial Innovation Policy

Understanding sectoral sources of aggregate productivity growth: A cross-country analysis

Full report

About this report

This report analyses the sectoral sources of labour productivity growth in a sample of economies at different stages of development over the last 20 years. In addition to this report, a summary report and eight economy-specific studies have been produced for China, France, Germany, Korea, Taiwan, Singapore, the United Kingdom and the United States. Together, they seek to inform policies aimed at boosting productivity by improving the understanding of how sectors account for aggregate productivity gains and losses and how this differs across economies.

Contributors

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Acknowledgements

This report has been made possible by core funding from the Gatsby Charitable Foundation.

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Cambridge, United Kingdom | 2022

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Executive summary

Since the global financial crisis of 2008, aggregate productivity growth has been sluggish in many developed and developing countries; however, there are stark differences across economies. Understanding the reasons behind this trend is essential for policy-makers.

This report draws from a cross-country data set to investigate the extent to which sectoral structures and dynamics explain the diversity in labour productivity gains and losses during the period between 1998 and 2017. The report looks at sector-level data in a sample of eight economies, at different stages of development, which account for over half of the world's economic output: China, France, Germany, Korea, Taiwan, Singapore, the United Kingdom and the United States.

Takeaway messages

- **Sectors contribute differently to productivity growth:** Across the eight economies examined, some sectors tend to be more productive and to grow faster than others. While some variations across economies exist, sectors such as finance, mining and quarrying,[1] information and communication, and manufacturing tend to have above-average levels of productivity and to experience faster productivity growth. With the exception of mining, we find that these sectors also tend to contribute the most to aggregate productivity growth. The magnitude of their contributions, however, depends on their relative size across economies. This basic, often overlooked, point has important implications for the way in which we analyse productivity growth. The rate at which national productivity grows is determined by the combined performance of individual sectors of the economy. An economy's aggregate productivity grows not only when its sectors become more productive but also when the participation of sectors with above-average levels of productivity increases.

- **The productivity growth effect of structural change:** The rise in the share of sectors with below-average levels of labour productivity, at the expense of sectors with above-average productivity, has slowed overall productivity growth, particularly in the UK. In the last two decades aggregate labour productivity growth has been largely explained by the labour productivity growth that takes place within sectors. However, we also find considerable effects on aggregate productivity growth as a result of ongoing structural change. When looking at the market economy only – that is, excluding sectors such as real estate, education and public administration – the growth of the participation of sectors with below-average productivity levels, at the expense of above-average productivity sectors, has more than halved the UK's overall productivity growth.

- **The manufacturing premium (and manufacturing loss penalty):** The manufacturing sector has been the main driver of productivity growth in economies where it accounts for more than 20% of GDP. Conversely, the loss of manufacturing has imposed a severe penalty on productivity growth, particularly in the UK. Manufacturing is one of the sectors with the fastest labour productivity growth among the economies analysed during the 1998–2017 period. Although deindustrialisation was a dominant trend in this period, the manufacturing sector contributed significantly to productivity growth in economies where it accounts for over 20% of

[1] Extraction of crude petroleum and natural gas represents around 80% of the gross value added of mining and quarrying.

GDP: almost half of the aggregate labour productivity growth in Taiwan; roughly a third in Korea and China; and a quarter in Germany. In contrast, manufacturing has made a negative contribution to productivity growth in the UK and US, where the participation of manufacturing in the economy has been the lowest among the economies analysed (10% and 11% of total output in 2017, respectively). In particular, the loss of manufacturing has imposed a penalty on UK productivity growth of three-quarters of a percentage point, on average, each year for the last two decades.

- **A diverse service landscape:** Services have contributed to productivity growth through their increasing size and productivity dynamism, but this is not equal across all service activities and economies. The shrinking of manufacturing has gone hand in hand with the expansion of service activities. Service sectors whose contribution to aggregate productivity growth has increased over the last two decades in the economies analysed include both activities with productivity levels that are above average, such as financial and insurance activities and professional, scientific and technical activities, and more labour-intensive activities with below-average productivity levels, such as wholesale and retail trade, human health and social work activities, and administrative and support services.

- **Developing national productivity strategies with sector-specific analyses:** Policies aimed at improving national productivity need to be grounded in a sound understanding of how productivity varies across sectors, the drivers of competitive advantage, and how these differences help to explain aggregate productivity gains and losses. Restricting policy analyses to aggregate productivity growth across the whole economy risks overlooking the variation between sectors within national economies and limits the evidence available to policy-makers. To be effective, productivity strategies must be based on granular knowledge of sector-specific opportunities and constraints. Understanding the drivers of competitive advantage that enable sectors to command higher levels of value-added is, therefore, critical to effective policy design.

- **Limitations of productivity measures:** Productivity measures have important limitations and should not be confused with efficiency metrics, particularly in predominantly non-market sectors, such as healthcare. Because productivity measures are based on value added measures, they suffer from similar limitations to those found in the measurement of GDP, from how value is mainly determined by market transactions, and the related undervaluing of non-market activities, to not accounting for the environmental and social costs of production. Although different methods have been developed to adjust the productivity measures of non-market services to quality, these are far from perfect and tend to underestimate the non-market value of the contribution of these sectors to society. Policy-makers should exercise caution when using productivity measures to monitor the performance of predominantly non-market sectors such as public administration and healthcare. Confusing productivity measures with efficiency metrics could lead to drawing the wrong conclusions about, for example, the optimal size of a sector or the adequate wage levels.

1. Introduction

This report provides insights into the extent to which different economic sectors help to explain recent trends in labour productivity growth across economies. This overview report is accompanied by economy-specific studies for China, France, Germany, Korea, Taiwan, Singapore, the United Kingdom and the United States. Together, they seek to inform policies aimed at boosting productivity by improving the understanding of how sectors explain aggregate productivity growth gains and losses and how this differs across economies with different structures and at different stages of development.

Sectors contribute differently to national aggregate productivity growth in function of their productivity levels, their relative weight in national output and employment, and their divergent growth trajectories over time. In this report we quantify the contribution of economic sectors to aggregate productivity growth over the last 20 years. An examination of the root causes of sectoral and aggregate productivity performance, including an assessment of the contribution of different factors of production, is outside the scope of this study.

This report addresses the following questions: (i) How does labour productivity performance compare across economies? (ii) Which sectors are the main sources of national labour productivity growth? And (ii) how do sectoral dynamics explain recent trends in aggregate productivity growth?

To address these questions, we decompose labour productivity growth rates into two main sub-components, as described in the methodology by Tang and Wang in 2004:[2] an *intra-industry growth component*; and an *allocation component*. The intra-industry component (also known as the *within effect*) captures the contribution of each industrial sector to overall labour productivity growth, given its rate of productivity growth and relative weight in the economy. The allocation effect (also known as the *between effect*) captures the contribution of the different sectors to aggregate productivity growth, given the changes in their relative size (changes in employment shares and relative output prices). Appendix II presents details of this decomposition.

The analysis is conducted for eight economies at different stages of development: China, France, Germany, Korea, Taiwan, Singapore, the United Kingdom and the United States. Together, these economies account for just over half (53%) of the world's economic output.[3] This sample allows us to analyse the distinct contribution of sectors to aggregate productivity growth in economies at different levels of development and with different economic structures.

The main period of analysis for the cross-economy examination is 1998–2017, which allows us to study major trends in the periods before and after the global financial crisis of 2008. Whenever possible, however, the most up-to-date data (at the time this analysis was conducted) is used to provide economy-specific highlights.

[2] Tang, J. and Wang, W. (2004). Sources of aggregate labour productivity growth in Canada and the United States. *Canadian Journal of Economics*, 37(2).
[3] World Bank national accounts data.

The report is structured as follows:

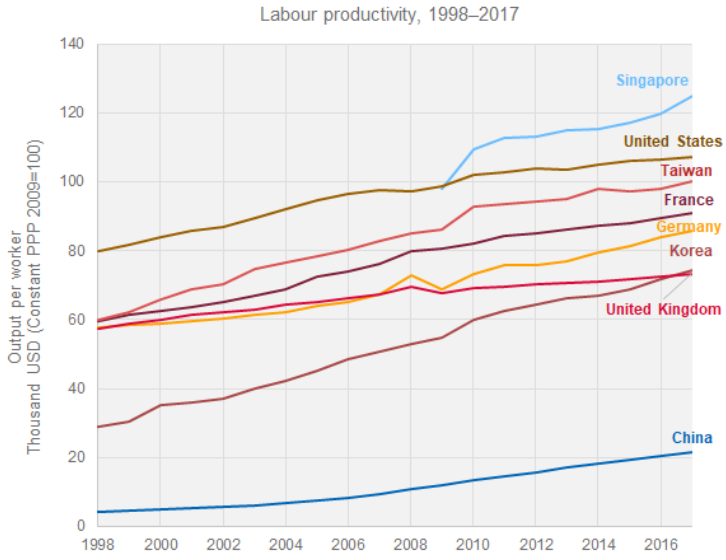
- Section 2 provides an overview of the trends in aggregate labour productivity growth for the 1998–2017 period for our sample of economies.
- Section 3 explains which sectors make the largest contributions to aggregate labour productivity growth.
- Section 4 describes how sectoral dynamics explain recent trends in aggregate productivity growth.
- Section 5 concludes by discussing the prospects for future productivity growth.
- Appendix I describes the variables and data sources used in this report.
- Appendix II explains the methodology used to decompose the overall labour productivity growth rate.
- Appendix III presents the results of the decomposition of aggregate productivity growth rates, excluding predominantly non-market sectors.

2. How does labour productivity performance compare across economies?

Since the global financial crisis of 2008, sluggish aggregate productivity growth has been a dominant trend among the economies examined in this report, as well as in most developed and developing economies. Global labour productivity growth decelerated from an average rate of 2.0% in 1998–2007 to a rate of 1.6% in 2008–19.[4] However, we observe stark differences across economies.

Figure 1 illustrates the productivity performance of our sample of economies for the 1997–2017 period. The sample includes: (i) emerging and developed economies that have experienced strong labour productivity growth during the period of analysis (China, Korea, Singapore and Taiwan); (ii) mature economies with weakening productivity growth, particularly since the global financial crisis (France, the United Kingdom and the United States); and (iii) a developed economy with a strong recovery in productivity growth after the financial crisis of 2008 (Germany).

FIGURE 1: WHOLE ECONOMY LABOUR PRODUCTIVITY GROWTH, 1998–2017, SELECTED ECONOMIES



Economy	Output per worker in 2017 (thousand USD, constant PPP, 2009 = 100)
Singapore	124,967
United States	107,075
Taiwan	100,075
France	90,791
Germany	85,815
Korea	74,431
United Kingdom	73,258
China	21,706

Economy	Growth rate, 1998–2017 (annual average)
China	8.9%
Korea	5.1%
Singapore[1/]	3.1%
Taiwan	2.7%
France	2.2%
Germany	1.7%
US	1.6%
UK	1.1%

Note: [1/] The 2010–17 period for Singapore.

Source: Authors' computation, based on data from: Asian Productivity Organization (APO) Productivity Database 2020 Ver.1 (5 August 2020); OECD Structural Analysis Database (2020 ed.); Singapore Department of Statistics; Singapore Ministry of Trade and Industry; Manpower Research & Statistics Department; Taiwan Statistical Bureau UK Office for National Statistics; US Bureau of Economic Analysis; and US Bureau of Labor Statistics.

[4] World Bank Development Indicators and ILOSTAT.

From the sample of economies analysed in this report, Singapore stands out with the highest level of output per worker in 2017, at US$124,967,[5] while China had the fastest labour productivity growth rate, at 8.3% on average, during the 1998–2017 period.

Despite this fast growth, productivity levels in China are still a fraction of those observed in developed economies, at US$21,706 output per worker in 2017. For instance, China's productivity levels are one-third of those observed in the United Kingdom and Korea and less than one-fifth of those in Singapore (Figure 1). However, because of its large workforce and fast productivity growth, China is now the second-largest economy in the world after the United States.[6]

Korea's labour productivity growth has also been remarkable, observing the second-highest growth rate in our sample (5.1%), behind only China. In 1998 Korea's output per worker was around half of that observed in the UK; by 2017 it was 2% higher than the UK (Figure 1).

TABLE 1: LABOUR PRODUCTIVITY GROWTH, 1998–2017, SELECTED ECONOMIES

Economy	Whole period of analysis (1998–2017)	Sub-periods			Changes between sub-periods (Δ%)	
		(1) Pre-crisis (1998–2007)	(2) Crisis (2008–10)	(3) Post-crisis (2011–17)	Crisis (2) vs pre-crisis (1)	Post-crisis (3) vs pre-crisis (1)
China	8.9%	9.5%	10.5%	7.3%	10.5%	-23.9%
Korea	5.1%	6.2%	5.7%	3.2%	-6.8%	-48.2%
Singapore	3.1%[1/]	N/A	N/A	1.9%	N/A	N/A
Taiwan	2.7%	3.8%	2.5%	1.1%	-34.1%	-71.3%
France	2.2%	2.8%	1.8%	1.4%	-35.6%	-49.2%
Germany	1.7%	1.7%	0.3%	2.3%	-83.1%	33.3%
US	1.6%	2.1%	1.8%	0.7%	-14.2%	-66.6%
UK	1.1%	1.7%	-0.5%	0.9%	-131.5%	-50.7%

Note: Economies are ranked from the highest average productivity growth rate in the whole period of analysis to the lowest. N/A, not available. [1/] The 2010–17 period for Singapore. Labour productivity measured as output per worker. While output per hour is more widely used to measure labour productivity, this table shows output per worker to allow comparisons among all economies in our sample (data on hours worked was not available for China).

Source: Authors' computation, based on data from: APO Productivity Database 2020 Ver.1 (5 August 2020); OECD STAN Industrial Analysis (2020 ed.); Singapore Department of Statistics; Singapore Ministry of Trade and Industry; Manpower Research & Statistics Department; Taiwan Statistical Bureau UK Office for National Statistics; US Bureau of Economic Analysis; and US Bureau of Labor Statistics.

As discussed in the introduction of this section, after the financial crisis of 2008 productivity growth slowed down across all of the economies examined here, with the exception of Germany. Factors that help to explain this trend include: the reallocation of labour towards labour-intensive service activities; weaker international trade flows after the global financial crisis of 2008; slower efficiency gains from technology adoption and skills development; and an ageing workforce.[7]

In the UK the labour productivity growth rate fell from an average of 1.7% during the pre-crisis period (1998–2007) to a rate of -0.5% during the crisis years (2008–10). The UK was the only economy in our sample for which the average rate of labour productivity growth (measured as

[5] Constant purchasing power parity (PPP), 2009 = 100.
[6] UNCTAD (2022). *China's structural transformation. What can developing countries learn?* New York: United Nations.
[7] Dieppe, A. (ed.) (2021). Global Productivity: Trends, Drivers, and Policies. Washington, DC: World Bank. doi:10.1596/978-1-4648-1608-6. License: Creative Commons Attribution CC BY 3.0 IGO; Asian Productivity Organization, APO (2022). APO Productivity Outlook 2022. Manufacturing labor productivity: Trends and linkages. Tokyo: Asian Productivity Organization.

output per worker) was negative during the crisis period (Table 1). The lack of productivity growth and failing to recover to pre-crisis levels have come to be known as the “productivity puzzle”.

Although this phenomenon is not specific to the UK, the magnitude of the UK shortfall appears more severe. France, Korea, Taiwan and the US have experienced a slowdown in growth rates since the financial crisis. China is the only economy in the sample to have seen an increase in the rate of labour productivity growth during the crisis (from an average of 9.5% in 1998–2007 to 10.5% in 2008–10). And while Korea and Taiwan continued to experience robust productivity growth rates during the crisis, these have been lower than those observed during the pre-crisis period.

Germany’s labour productivity was the second most impacted during the global financial crisis of 2008, after the UK. Productivity growth declined from 1.7% in 1998–2007 to 0.3% in 2008–10; however, unlike the UK, Germany managed to recover its productivity dynamism in the decade that followed the crisis.

From the sample of economies examined, Germany is the only country to have experienced faster productivity growth in the post-crisis period (2.3%) than the decade before the crisis (1.7%). Factors likely to explain this strong recovery include a competitive export position supported by the euro and the restructuring of its labour market; the expansion of German value chains to Eastern Europe; and efficiency gains based on management improvements and technology adoption.[8] Although the restructuring of the German labour market implied the decentralisation of wage negotiations, restraining wage growth and helping Germany’s competitiveness, studies have argued that this was achieved at the cost of extreme wage inequality.[9]

[8] Marin, D. (2018). Explaining Germany’s Exceptional Recovery. London: Centre for Economic Policy Research.
[9] Micossi, S., D’Onofrio, A. and Peirce, F. (2018). On German external imbalances. Policy Insights. Centre for European Policy Studies.

3. How do sectors contribute to aggregate productivity growth?

Sectors differ in their size, exposure to competition, potential for technological upgrading and profit margins, among other characteristics.[10] Because of these differences, some sectors tend to contribute to aggregate productivity growth more than others. Across countries, sectors such as mining and quarrying, manufacturing, financial and insurance activities, and information and communication tend to be more productive and to experience faster productivity growth.

Table 2 presents sector productivity levels (relative to those of the total economy) in 2017. The table shows how, for production activities, mining and quarrying and manufacturing tend to have productivity levels above the national averages, while construction and agriculture tend to have productivity levels below the national average across the eight economies.

For service activities, the financial and insurance and information and communication sectors present the highest productivity levels. With the exception of China, these sectors are between 1.5 and 2 times more productive than the national average. In comparison, accommodation and food services activities have productivity levels that are well below the average, ranging from one to two-thirds of the national average.

Caution is required when interpreting the productivity levels of real estate activities, since imputed rents from owner-occupied dwellings tend to be included in the value added of the sector and this boosts labour productivity measures above those observed in other sectors. This is also the case for China's financial sector, which includes data from real estate activities.

Table 3 presents average labour productivity growth rates by sector for the 1998–2017 period. Across the eight economies examined, manufacturing exhibits among the fastest rates. These are faster than the whole economy, with the exception of China, where manufacturing productivity growth was 6 percentage points lower than the productivity growth of the whole economy. With the exception of the UK, Korea and Taiwan, mining and quarrying also shows productivity gains above those observed for the whole economy.

The information and communication and financial and insurance sectors, as well as showing high labour productivity levels, experienced fast productivity growth between 1998 and 2017, although this varies across economies. In Taiwan, the US and the UK the information and communication sector has observed productivity growth rates faster than those seen for the whole economy. Financial and insurance activities also show productivity growth rates faster than the whole economy, particularly in France, Germany, Singapore, the US and the UK.

Although agriculture shows productivity levels below the national average, its labour productivity has grown faster than the whole economy in the last two decades. Wholesale and retail trade; repair of motor vehicles and motorcycles is another sector with relatively low productivity but it has observed faster growth than the national average in Germany, Korea, Singapore and the US.

[10] Atkinson, R. (2021). Sectoral Policies to Drive Productivity Growth.

TABLE 2: SECTORAL PRODUCTIVITY LEVELS (RATIO RELATIVE TO WHOLE ECONOMY), 2017

Economic sectors	Output per worker at current prices, 2017 (as ratio of the output per worker of the whole economy)								
	China	France	Germany	Korea	Singapore	Taiwan	US	UK	Average of the eight economies
Real estate activities (L)	N/A	9.80	9.88	3.93	1.56	6.06	7.96	7.97	6.74
Financial and insurance activities (K)	12.92[1/]	1.37	1.58	1.94	2.59	1.47	1.92	2.63	3.30
Electricity, gas and water supply; sewerage, waste management and remediation activities (D and E)	4.08	2.28	2.33	3.41	N/A	2.65	4.60	2.73	3.16
Mining and quarrying (B)	3.56	1.68	1.22	1.62	N/A	1.43	3.54	4.86	2.56
Information and communication (J)	N/A	1.68	1.58	1.56	1.20	1.19	2.77	1.46	1.63
Education (P)	N/A	0.76	0.81	0.73	N/A	5.07	0.52	0.68	1.43
Manufacturing (C)	1.56	1.21	1.33	1.72	1.55	1.00	1.41	1.27	1.38
Public administration and defence; compulsory social security (O)	N/A	0.90	1.03	1.61	N/A	N/A	0.93	1.14	1.12
Professional, scientific and technical activities (M)	N/A	1.11	0.99	1.46	0.93	0.72	1.17	0.94	1.05
Transportation and storage (H)	1.60	0.93	0.86	0.66	1.07	0.88	0.80	0.84	0.95
Wholesale and retail trade; repair of motor vehicles and motorcycles (G)	0.87	0.78	0.75	0.56	1.44	0.80	0.82	0.69	0.84
Other service activities	0.70	0.51	0.66	0.36	0.53	1.87	0.48	0.67	0.72
Construction (F)	0.73	0.90	0.84	0.81	0.34	0.44	0.77	0.96	0.72
Administrative and support service activities (N)	N/A	0.69	0.68	0.66	0.91	0.38	0.64	0.60	0.65
Arts, entertainment and recreation (R)	N/A	0.65	0.88	0.00	N/A	1.03	0.62	0.56	0.63
Human health and social activities (Q)	N/A	0.66	0.58	0.62	N/A	0.71	0.59	0.59	0.63
Agriculture, forestry and fishing (A)	0.30	0.64	0.66	0.42	N/A	N/A	0.32	0.55	0.48
Activities of households (T)	N/A	0.12	0.31	N/A	N/A	N/A	N/A	0.91	0.44
Accommodation and food service activities (I)	N/A	0.65	0.38	0.29	0.32	0.45	0.36	0.42	0.41
Whole economy	**1.0**	**1.0**	**1.0**	**1.0**	**1.0**	**1.0**	**1.0**	**1.0**	**1.0**

Note: N/A, not available. [1/] For China, the financial and insurance sector (K) also includes real estate activities.

Source: Authors' computation based on data from: APO Productivity Database 2020 Ver.1 (5 August 2020); OECD STAN Industrial Analysis (2020 ed.); Singapore Department of Statistics; Singapore Ministry of Trade and Industry; Manpower Research & Statistics Department; Taiwan Statistical Bureau; UK Office for National Statistics; US Bureau of Economic Analysis; and US Bureau of Labor Statistics.

TABLE 3: LABOUR PRODUCTIVITY GROWTH BY SECTOR, 1998–2017

Economic sectors	China	France	Germany	Korea[1/]	Singapore [2/]	Taiwan[3/]	US	UK	Average of the eight economies
Manufacturing (C)	8.3%	2.5%	3.0%	5.7%	7.0%	6.0%	3.7%	4.2%	5.1%
Electricity, gas and water supply; sewerage, waste management and remediation activities (D and E)	13.0%	2.3%	3.5%	7.7%	N/A	2.4%	1.8%	-1.0%	4.3%
Agriculture, forestry and fishing (A)	6.8%	3.3%	3.3%	4.2%	N/A	N/A	2.9%	4.7%	4.2%
Information and communication (J)	N/A	1.4%	1.6%	1.6%	1.1%	5.0%	6.5%	9.7%	3.8%
Financial and insurance activities (K)	6.7%[4/]	3.0%	2.9%	3.7%	4.5%	2.0%	2.3%	2.0%	3.4%
Wholesale and retail trade; repair of motor vehicles and motorcycles (G)	7.1%	1.7%	2.4%	5.5%	4.0%	2.2%	2.1%	0.7%	3.2%
Mining and quarrying (B)	11.6%	4.8%	4.2%	2.2%	N/A	1.1%	2.6%	-5.2%	3.0%
Transportation and storage (H)	7.3%	2.4%	1.9%	4.4%	1.0%	2.7%	0.6%	0.1%	2.6%
Public administration and defence; compulsory social security (O)	N/A	2.6%	2.7%	4.3%	N/A	N/A	0.0%	1.7%	2.3%
Activities of households (T)	N/A	0.1%	1.5%	N/A	N/A	N/A	N/A	4.6%	2.1%
Administrative and support service activities (N)	N/A	1.0%	0.4%	2.4%	7.6%	0.4%	N/A	0.2%	2.0%
Construction (F)	6.9%	2.7%	2.1%	4.0%	1.7%	-0.2%	-0.9%	-0.3%	2.0%
Real estate activities (L)	N/A	3.4%	1.2%	2.4%	0.8%	2.3%	1.9%	-1.5%	1.5%
Arts, entertainment and recreation (R)	N/A	2.0%	1.0%	4.7%	N/A	0.6%	0.6%	0.0%	1.5%
Other service activities	6.9%	1.8%	0.8%	N/A	0.9%	2.4%	-1.2%	-1.3%	1.5%
Education (P)	N/A	2.3%	1.1%	3.9%	N/A	1.2%	-0.4%	-1.8%	1.1%
Accommodation and food service activities (I)	N/A	2.1%	1.2%	4.1%	1.6%	-1.8%	0.0%	-0.2%	1.0%
Professional, scientific and technical activities (M)	N/A	2.2%	-0.7%	3.2%	-1.0%	1.0%	1.4%	0.4%	0.9%
Human health and social activities (Q)	N/A	2.7%	1.6%	-0.4%	N/A	-1.2%	0.6%	0.0%	0.6%
Whole economy	**8.9%**	**2.2%**	**1.7%**	**4.2%**	**3.1%**	**2.7%**	**1.6%**	**1.1%**	**3.2%**

Note: N/A, not available. [1/] For Korea, the 2005–17 annual average is computed; [2/] for Singapore, the 2010–17 annual average is computed; [3/] Taiwan's total productivity excludes sectors A and O; [4/] for China, the financial and insurance sector (K) also includes real estate activities.

Source: Authors' computation, based on data from: APO Productivity Database 2020 Ver.1 (5 August 2020); OECD STAN Industrial Analysis (2020 ed.); Korea Productivity Center; Singapore Department of Statistics; Singapore Ministry of Trade and Industry; Manpower Research & Statistics Department; Taiwan Statistical Bureau; UK Office for National Statistics; US Bureau of Economic Analysis; and US Bureau of Labor Statistics.

In addition to their productivity levels and growth, the contribution of sectors to aggregate productivity depends on their relative size in the economy and how this changes over time. As Figure 2 shows, the economies examined present different structures. China has the largest agricultural sector, accounting for 7.9% of the output and 26.5% of the employment in 2017. In the rest of the economies, this sector represents less than 3% of the total economy in terms of output and employment. The exception is Korea, where agricultural employment accounts for nearly 5% of the labour force.

The participation of agriculture in the economy has declined across the eight economies; China and Korea have seen the most substantial changes. In China, agriculture output shares declined by 9.5 percentage points between 1998 and 2017, while employment shares fell by 23.3 percentage points (Figure 3). To give a sense of scale, around 150 million workers left farms in China between 1998 and 2017. In Korea, in the same period, output shares fell by 2.4 percentage points, while employment shares fell by 7 percentage points.

Most of the economies examined show relatively large manufacturing sectors, with output shares above 20% in China, Germany, Korea and Singapore and above 30% in Taiwan in 2017. Manufacturing employment shares in these economies range from around 17% in Korea and Germany to 36% in Taiwan. The exceptions are France, the UK and the US. Manufacturing in these economies accounts for less than 12% of the output and less than 10% of the employment of the total economy (Figure 2).

Deindustrialisation is a common trend among the eight economies. In the last two decades manufacturing output shares have declined in China, France, Singapore, the US and the UK. In terms of output, the deepest falls are seen in Singapore (-8.6 percentage points between 2005 and 2017) and the UK (-6 percentage points between 1998 and 2017). In terms of employment, with the exception of China, the rest of the economies experienced a decline in the participation of manufacturing. The deepest fall between 1998 and 2017 is seen in Taiwan (-5.1 percentage points) and the UK (-7.1 percentage points) (Figure 3).

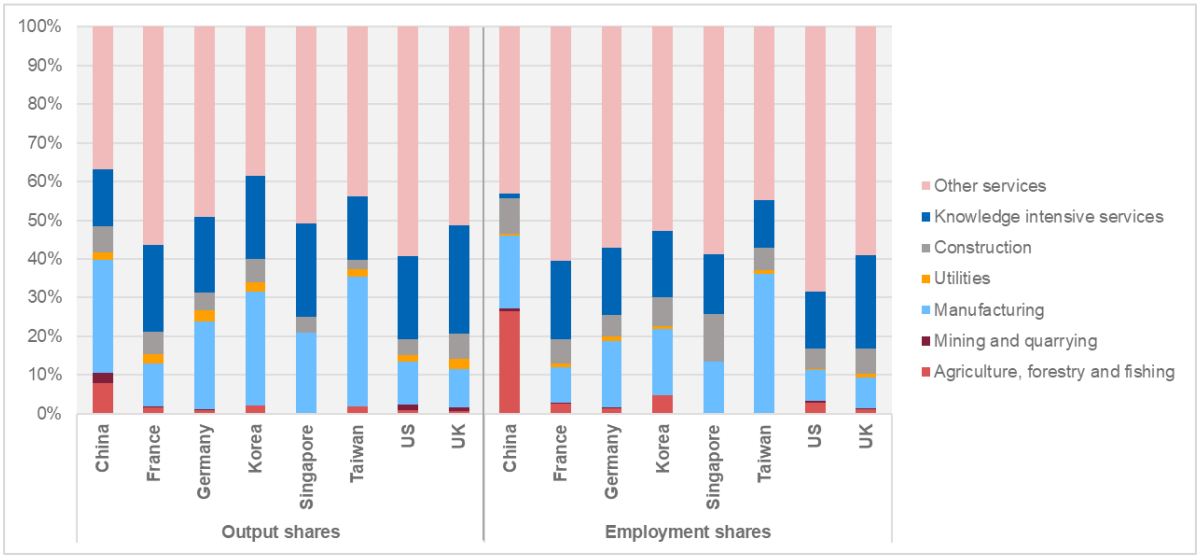
The participation of knowledge-intensive services,[11] such as financial services and information and communication, is particularly large in the UK and France, where the output and employment shares of these services represent more than 20% of output and employment of the total economy. Economies where knowledge-intensive services have seen the largest expansion in the last two decades include Singapore (4.3 percentage points) and the UK (5.4 percentage points), in terms of output shares, and Korea (4.8 percentage points) in terms of employment shares.

France and the US show the largest participation in the economy of activities classified as other services.[12] These accounted for more than 50% of the output and more than 60% of the employment of these economies in 2017 (Figure 2). The largest expansion of these services is

[11] Knowledge-intensive services include: information and communication (J), financial and insurance activities (K), professional, scientific and technical activities (M) and education (P), with the exception of China, which groups together financial intermediation, real estate, renting and business activities.
[12] Other services include: wholesale and retail (G), transportation and storage (H), accommodation and food service activities (I), real estate activities (L), administrative and support service activities (N), public administration and defence (O), human health and social work activities (Q), arts, entertainment and recreation (R) and other service activities (S, T), with the exception of China, which groups together wholesale and retail (G), transportation and storage (H), and community, social and personal services.

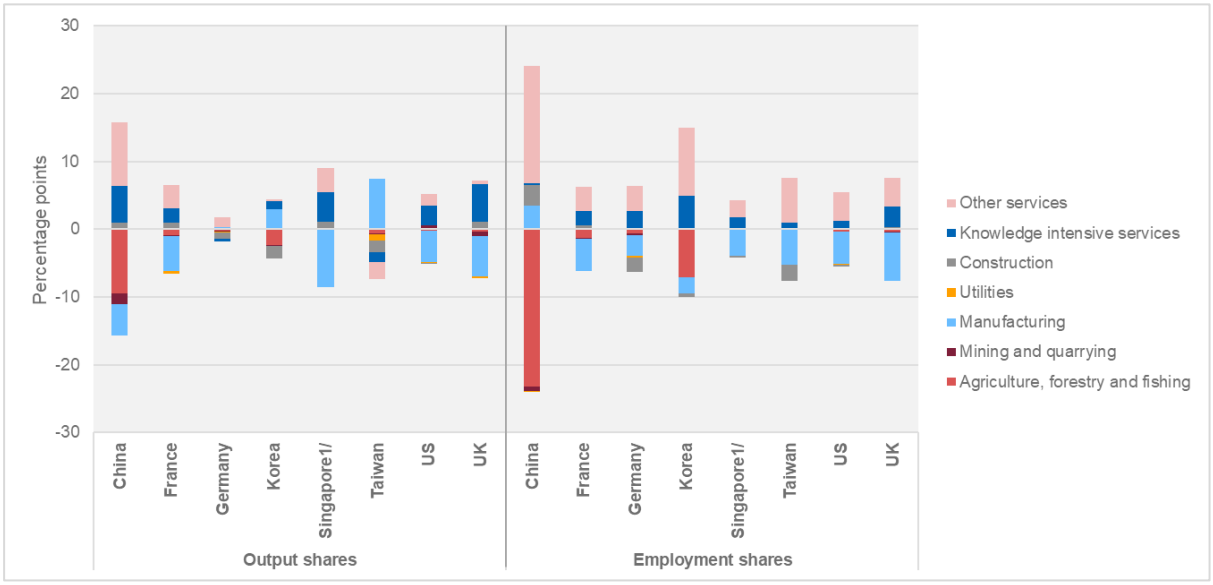
observed in China, in terms of output, and in China and Korea in terms of employment. Section 4 provides a more detailed analysis of the changes observed in the services sector.

FIGURE 2: OUTPUT AND EMPLOYMENT SHARES ACROSS ECONOMIES AND BROAD SECTORS, 2017



Source: Authors' computation, based on data from: APO Productivity Database 2020 Ver.1 (5 August 2020); OECD STAN Industrial Analysis (2020 ed.); Korea Productivity Center; Singapore Department of Statistics; Singapore Ministry of Trade and Industry; Manpower Research & Statistics Department; Taiwan Statistical Bureau; UK Office for National Statistics; US Bureau of Economic Analysis; and US Bureau of Labor Statistics.

FIGURE 3: CHANGES IN OUTPUT AND EMPLOYMENT SHARES ACROSS ECONOMIES AND BROAD SECTORS, 1998–2017



Source: Authors' computation, based on data from: APO Productivity Database 2020 Ver.1 (5 August 2020); OECD STAN Industrial Analysis (2020 ed.); Korea Productivity Center; Singapore Department of Statistics; Singapore Ministry of Trade and Industry; Manpower Research & Statistics Department; Taiwan Statistical Bureau; UK Office for National Statistics; US Bureau of Economic Analysis; and US Bureau of Labor Statistics.

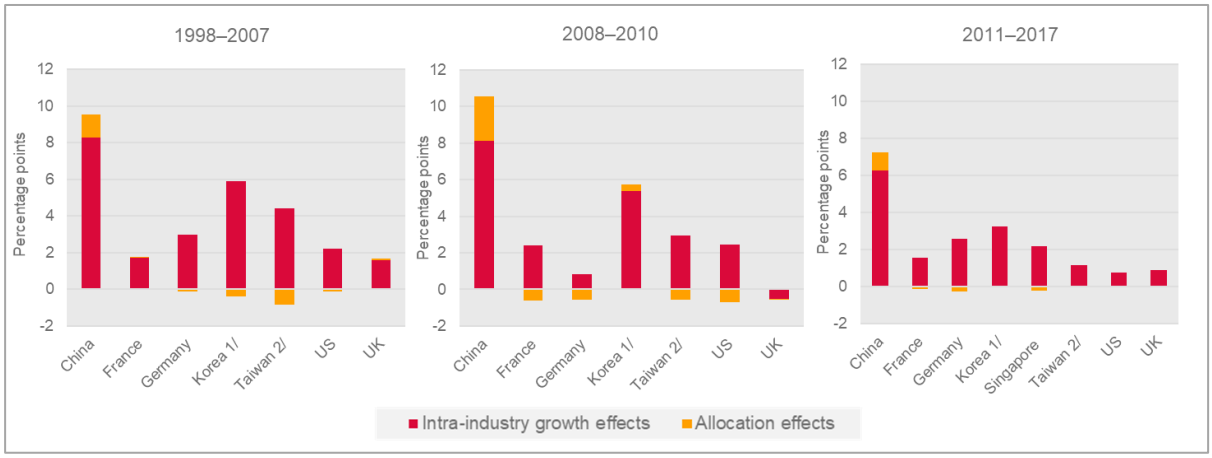
4. How do sectoral dynamics explain recent trends in aggregate productivity growth?

In order to understand which – and how – sectors help to explain recent trends in national labour productivity growth across our sample of economies, we apply the generalised exactly additive decomposition (GEAD) by Tang and Wang.[13] This methodology recognises that economy-wide labour productivity growth rates depend on: (i) sectoral productivity growth rates, (ii) changes in sectoral labour input shares and (iii) real output price changes.

Productivity growth rates are decomposed into two main components: (i) *an intra-industry growth* component, which captures the productivity growth of each industrial sector and its relative weight in the overall economy; and (ii) *an allocation effect*, which captures changes in the relative size of sectors over time, considering both employment shares and relative output prices. The *total contribution* of a sector to national productivity growth is the *sum of the intra-industry growth effect and the allocation effect*. Appendix II provides more details of this decomposition.

We find that across the economies and time periods examined, labour productivity growth is largely explained by an intra-industry productivity growth effect rather than by the sectoral allocation effects between low- and high-productivity sectors (Figure 4). However, the effects are not uniform across economies or time periods. Allocation effects explained around one-quarter of the productivity growth shortfall in Taiwan in 1998–2007. They also explained approximately one-quarter of China's labour productivity growth rate during 2008–10 and helped to explain the productivity growth shortfall in economies such as Germany, the US, France and Taiwan during the same period.

FIGURE 4: DECOMPOSITION OF AGGREGATE PRODUCTIVITY GROWTH 1998–2017, SELECTED ECONOMIES



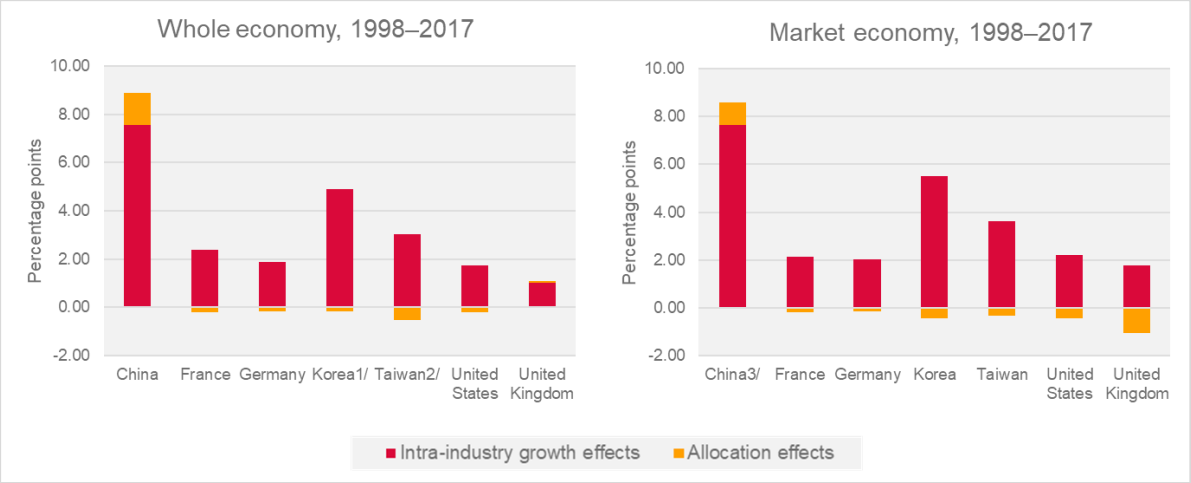
Note: Labour productivity measured as output per worker. 1/ For Korea, data on real estate, professional, scientific and technical activities, and administrative and support service activities, is excluded for the 1998–2004 period because of data unavailability. 2/ The decomposition for Taiwan excludes agriculture, forestry and fishing, and public administration and defence, because of data unavailability.

Source: Authors' computation, based on data from: APO Productivity Database 2020 Ver.1 (5 August 2020); OECD STAN Industrial Analysis (2020 ed.); Singapore Department of Statistics; Singapore Ministry of Trade and Industry; Manpower Research & Statistics Department; Taiwan Statistical Bureau UK Office for National Statistics; US Bureau of Economic Analysis; and US Bureau of Labor Statistics.

[13] Tang, J. and Wang, W. (2004). Sources of aggregate labour productivity growth in Canada and the United States. *Canadian Journal of Economics*, 37(2).

Focusing the analysis on those sectors where most of the transactions occur in the market, that is, excluding sectors such as real estate, education, public administration and healthcare, we observe how allocation effects become more negative in Korea, the US and the UK (Figure 5). In the UK this allocation effect (-1.04 percentage points) is even larger than the aggregate productivity growth (0.75 percentage points) experienced by the market economy in the 1998–2017 period.

FIGURE 5: COMPARISON OF DECOMPOSITION OF AGGREGATE PRODUCTIVITY GROWTH FOR THE WHOLE ECONOMY AND THE MARKET ECONOMY, 1998–2017



Note: Labour productivity measured as output per worker. Breakdown of the market economy not available for Singapore. 1/ For Korea, data on real estate, professional, scientific and technical activities, and administrative and support service activities, is excluded for the 1998–2004 period because of data unavailability. 2/ The decomposition for Taiwan excludes agriculture, forestry and fishing, and public administration and defence, because of data unavailability. 3/ The decomposition for China only excludes the real estate sector because of data unavailability.

Source: Authors' computation, based on data from: APO Productivity Database 2020 Ver.1 (5 August 2020); OECD STAN Industrial Analysis (2020 ed.); Singapore Department of Statistics; Singapore Ministry of Trade and Industry; Manpower Research & Statistics Department; Taiwan Statistical Bureau UK Office for National Statistics; US Bureau of Economic Analysis; and US Bureau of Labor Statistics.

Manufacturing is the main sectoral source of productivity growth in the economies with a relatively large manufacturing base, such as Taiwan (48%), Korea (32%), China (29%) and Germany (24%). However, as the sector contracted in the last two decades and lost its dynamism after the global financial crisis, its contribution to aggregate productivity growth has slowed down.

Because of its high productivity growth rates and relatively large output shares (intra-industry growth effect), manufacturing made a sizeable contribution to aggregate productivity growth in 1998–2017 in Taiwan (48% of an overall growth rate of 2.4%), Korea (32% of an overall growth rate of 4.3%),[14] China (29% of an overall growth rate of 8.9%) and Germany (24% of an overall growth rate of 1.7%) (Table 4).

[14] The 2005–17 period for Korea.

TABLE 4: CONTRIBUTION TO PRODUCTIVITY GROWTH BY ECONOMIC SECTOR, 1998–2017, SELECTED ECONOMIES

Economic sectors	China	France	Germany	Korea	Singapore*	Taiwan	US	UK	Average of the eight economies
Manufacturing (C)	28.6%	1.6%	24.4%	32.1%	15.4%	47.5%	-2.7%	-17.7%	16.2%
Wholesale and retail trade; repair of motor vehicles and motorcycles (G)	11.2%	9.1%	9.5%	7.6%	18.3%	20.6%	7.7%	3.7%	11.0%
Human health and social activities (Q)	N/A	11.9%	10.9%	6.4%	N/A	5.0%	11.4%	15.8%	10.2%
Real estate activities (L)	N/A	16.5%	9.5%	6.4%	2.2%	8.3%	16.6%	6.6%	9.5%
Financial and insurance activities (K)	13.9%	4.0%	2.5%	4.9%	16.2%	4.4%	10.4%	16.5%	9.1%
Professional, scientific and technical activities (M)	N/A	11.5%	6.2%	8.0%	4.4%	3.3%	11.9%	16.8%	8.9%
Administrative and support service activities (N)	N/A	7.2%	8.9%	4.3%	15.6%	3.7%	7.8%	10.1%	8.2%
Public administration and defence; compulsory social security (O)	N/A	6.1%	4.2%	7.5%	N/A	N/A	10.7%	3.5%	6.4%
Information and communication (J)	N/A	5.7%	5.9%	3.2%	5.2%	4.9%	6.7%	10.9%	6.1%
Other service activities	19.4%	0.1%	0.2%	2.4%	16.8%	3.2%	0.6%	0.2%	5.3%
Construction (F)	6.6%	7.3%	0.6%	4.5%	-1.8%	-1.6%	4.7%	12.8%	4.1%
Transportation and storage (H)	8.2%	5.1%	5.3%	3.1%	4.1%	1.1%	3.3%	2.7%	4.1%
Education (P)	N/A	5.2%	4.9%	5.2%	N/A	-4.1%	2.3%	9.7%	3.9%
Accommodation and food service activities (I)	N/A	3.8%	1.8%	2.1%	3.3%	3.9%	4.5%	4.6%	3.4%
Arts, entertainment and recreation (R)	N/A	2.2%	1.6%	N/A	N/A	0.9%	1.5%	3.3%	1.9%
Activities of households (T)	N/A	1.1%	1.1%	N/A	N/A	N/A	N/A	2.8%	1.6%
Electricity, gas, steam and air conditioning supply (D)	3.5%	0.7%	1.3%	2.1%	N/A	0.1%	N/A	1.2%	1.5%
Water supply; sewerage, waste management and remediation activities (E)	N/A	1.1%	1.2%	N/A	N/A	0.8%	N/A	0.9%	1.0%
Agriculture, forestry and fishing (A)	5.5%	-0.1%	0.3%	0.1%	N/A	N/A	-0.2%	-1.1%	0.8%
Mining and quarrying (B)	3.7%	0.0%	-0.2%	0.1%	N/A	-0.3%	2.4%	-3.3%	0.3%
Total	100%	100%	100%	100%	100%	100%	100%	100%	100%
Aggregate productivity growth rate	8.90	2.17	1.72	4.26	3.12	2.43	1.55	1.08	3.15

Note: Decomposition based on output per worker. Figures may not add up to the total because of rounding. [1/] For Korea, the 2005–17 annual average is computed. [2/] For Singapore, the 2010–17 annual average is computed and no disaggregated data is available for sectors A, B, D and E. [3/] Taiwan's decomposition of productivity growth excludes agriculture, forestry and fishing, and public administration and defence, because of a lack of data.

Source: Authors' computation based on data from: APO Productivity Database 2020 Ver.1 (5 August 2020); OECD STAN Industrial Analysis (2020 ed.); Singapore Department of Statistics; Singapore Ministry of Trade and Industry; Manpower Research & Statistics Department; Taiwan Statistical Bureau; UK Office for National Statistics; US Bureau of Economic Analysis; and US Bureau of Labor Statistics.

As can be seen on the right-hand panel of Figure 6, except in the case of China, manufacturing labour productivity growth rates were above the national average across all of these economies during the 1998–2017 period. These ranged from 8.3% in China to 2.5% in France. However, manufacturing productivity growth has slowed down since the financial crisis, as shown in the third panel of Figure 7.

The slower productivity growth of the manufacturing sector has been linked to weaker global trade.[15] While in the pre-crisis period (1998–2007) world exports grew at an average annual rate of 4.9%, during the global financial crisis and its aftermath (2008–10) exports grew by 2.0%, and in the decade that followed (2011–17) world exports grew by only 1.2%.[16]

Among our sample of economies, the slowdown of labour productivity growth was particularly steep in the US and the UK. Manufacturing productivity growth (measured as output per worker) slowed down in the UK from a rate of 7.2% in 1998–2007 to 0.7% in 2011–17; meanwhile, in the US it did not experience any growth at all in the post-crisis period (Figure 6).

FIGURE 6: MANUFACTURING LABOUR PRODUCTIVITY GROWTH, 1998–2017

Note: 1/ For Singapore, the 2010–17 annual average is computed.

Source: Authors' computation, based on data from: APO Productivity Database 2020 Ver.1 (5 August 2020); Korea Productivity Center; OECD STAN Industrial Analysis (2020 ed.); Singapore Department of Statistics; Singapore Ministry of Trade and Industry; Manpower Research & Statistics Department; Taiwan Statistical Bureau; UK Office for National Statistics; US Bureau of Economic Analysis; and US Bureau of Labor Statistics.

The impact of slower productivity growth in manufacturing concurs with shrinking output and employment shares, as discussed in Section 3. The largest contraction of manufacturing output shares was observed in Singapore (-8.6 percentage points in 2005–17), the UK (-6.0 percentage points in 1998–2017) and China (-4.6 percentage points in 1998–2017). In terms of employment

[15] Asian Productivity Organization, APO (2022). APO Productivity Outlook 2022. Manufacturing labor productivity: Trends and linkages. Tokyo: Asian Productivity Organization.
[16] World Bank (2022). World Integrated Trade Solution.

shares (1998–2017) these changes are more accentuated in the UK (-7.1 percentage points), Taiwan (-5.1 percentage points), France (-4.8 percentage points) and the US (-4.8 percentage points) (Table 5).

There have, however, been exceptions. Manufacturing output shares increased in Taiwan (7.4 percentage points), Korea (3.0 percentage points) and Germany (0.3 percentage points) between 1998 and 2017. In terms of employment, the only exception is China, where the share of manufacturing employment increased by 3.4 percentage points during the period of analysis (Table 5). However, in absolute terms, Korea and Taiwan also saw increases in manufacturing employment between 1998 and 2017.

Although Singapore experienced among the largest contractions in manufacturing shares, in our sample the trend seems to have been reversing in recent years, with manufacturing output shares above 20% (see country report). This is likely to be linked to an explicit commitment by the government to prioritise manufacturing as an engine of Singapore's economy. In the 10-year "Manufacturing 2030" plan, announced in 2021, Singapore's government set the goal to grow manufacturing value added by 50% while maintaining a share of around 20% of the gross domestic product.[17]

TABLE 5: CHANGES IN MANUFACTURING OUTPUT AND EMPLOYMENT SHARES, 1998–2017

Economy	Output shares			Employment shares		
	1998	2017	Change (pp.) 1998–2017	1998	2017	Change (pp.) 1998–2017
China	33.9%	29.3%	-4.6	15.4%	18.8%	3.4
France	16.2%	11.2%	-5.2	14.1%	9.3%	-4.8
Germany	22.5%	22.8%	0.3	20.2%	17.2%	-3.0
Korea	26.5%	29.5%	3.0	19.5%	17.1%	-2.4
Singapore	N/A	20.6%	-8.6[1/]	N/A	13.4%	-3.9[2/]
Taiwan	26.1%	33.5%	7.4	41.2%	36.2%	-5.1
US	15.8%	11.2%	-4.6	12.7%	7.9%	-4.8
UK	16.0%	10.0%	-6.0	15.0%	7.9%	-7.1

Note: N/A, not available. [1/]2005–17 change; [2/]2009–17 change. Shares computed over total economy, except Taiwan's employment shares, which are computed over a total value that excludes agriculture, forestry and fishing, and public administration and defence, because of a lack of data for these industries.

Source: Authors' computation, based on data from: OECD STAN Industrial Analysis (2020 ed.); APO Productivity Database 2020 Ver.1 (5 August 2020); Singapore Department of Statistics; Singapore Ministry of Trade and Industry; Manpower Research & Statistics Department; Taiwan Statistical Bureau; UK Office for National Statistics; US Bureau of Economic Analysis; and US Bureau of Labor Statistics.

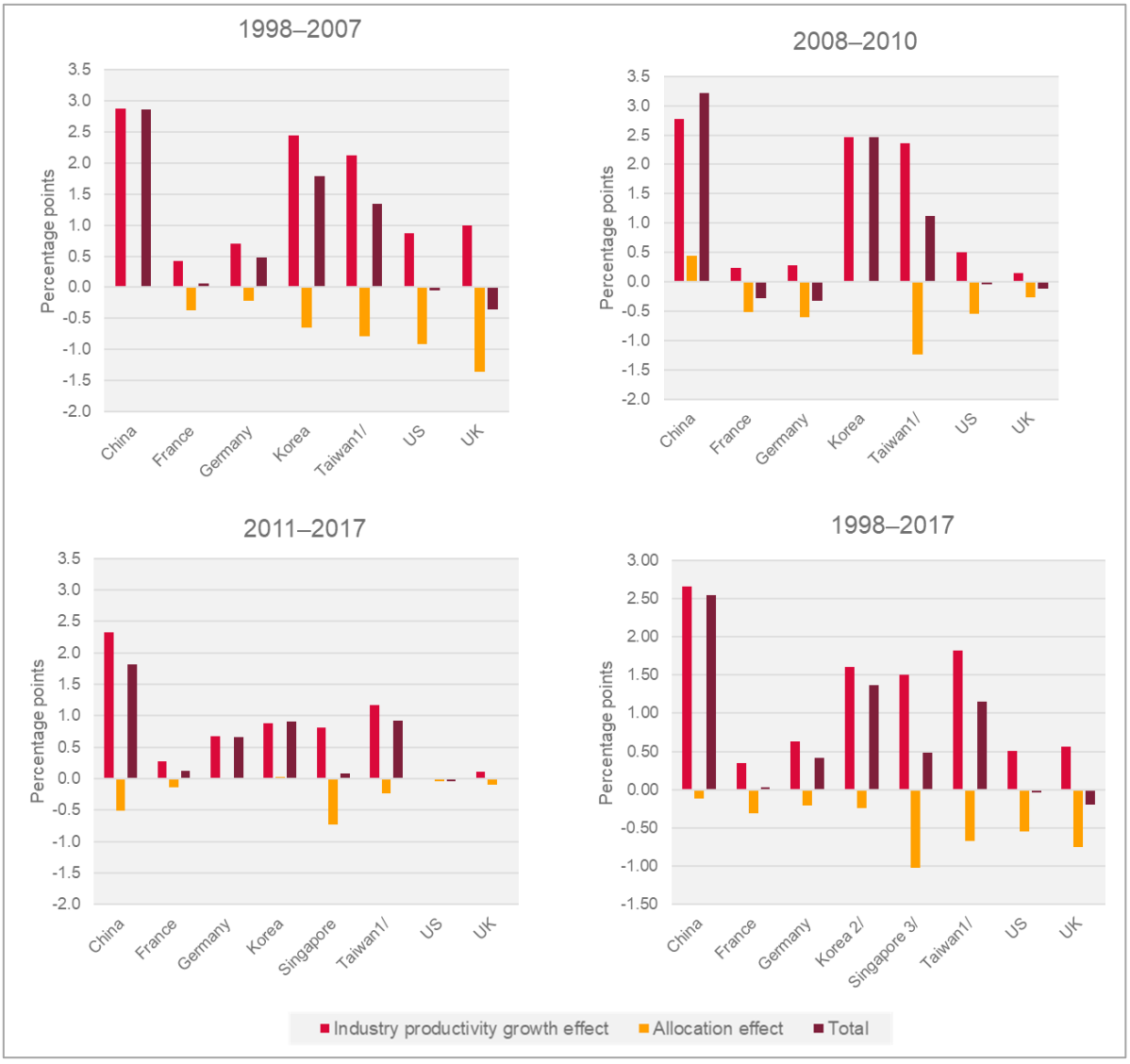
In some economies sluggish productivity growth and smaller output shares have resulted in smaller intra-industry productivity growth effects for manufacturing, as illustrated in Figure 7. In addition, lower employment shares explain the negative allocation effects, mainly observed between 1998 and 2010. For the whole period analysed, these negative allocation effects range from -0.12 percentage points in China (1998–2017) to -1.02 percentage points in Singapore (2011–17), in annual terms.

The effects of a shrinking manufacturing sector are more apparent at the beginning of the sample period, particularly in the UK, the US, Taiwan, Korea and France. It is in the 1998–2007 sub-period that we see the largest negative allocation effects, ranging from -0.2 percentage points in Germany

[17] Singapore Economic Development Board (2021). Singapore seeking frontier firms for 'Manufacturing 2030'.

to -1.4 percentage points in the UK. In the aftermath of the financial crisis the largest negative allocation effects were observed in Taiwan (-1.2 percentage points.), Germany (-0.6 percentage points) and France (-0.5 percentage points). However, these faded out, to some extent, in the decade after the crisis (2011–17), as can be observed in Figure 7.

FIGURE 7: CONTRIBUTIONS OF MANUFACTURING TO AGGREGATE PRODUCTIVITY GROWTH, 1998–2017



Note: Decomposition based on output per worker. [1/] Taiwan's decomposition of productivity growth excludes agriculture, forestry and fishing, and public administration and defence, because of data unavailability. [2/] For Korea, the 2005–17 annual average is computed. [3/] For Singapore, the 2010–17 annual average is computed.

Source: Authors' computation, based on data from: APO Productivity Database 2020 Ver.1 (5 August 2020); OECD STAN Industrial Analysis (2020 ed.); Singapore Department of Statistics; Singapore Ministry of Trade and Industry; Manpower Research & Statistics Department; Taiwan Statistical Bureau; UK Office for National Statistics; US Bureau of Economic Analysis; and US Bureau of Labor Statistics.

This deindustrialisation is reflected in a negative contribution from manufacturing to aggregate productivity growth, through the allocation effect. This is because resources are shifted away from the generally most productive sector, namely, manufacturing. With the exception of the US and the UK, these negative effects are counteracted by the positive and relatively large intra-industry productivity growth effects in manufacturing. In the economies where manufacturing contributes positively to aggregate productivity growth, its overall contribution ranges from 1.6% (of an overall growth rate of 2.2%) in France to 47.5% in Taiwan (of an overall growth rate of 2.4%) (Table 4).

A smaller manufacturing base and slower productivity growth explain why manufacturing contributes less to aggregate productivity growth in France, the UK and the US than it does in China, Germany, Korea, Singapore and Taiwan. The UK and US manufacturing sectors exhibit the lowest productivity growth rates of all the economies analysed (Figure 6), and their size is much smaller (Table 5) than that observed in the other six economies (with the exception of France). While the contraction of manufacturing is a trend that is shared across the eight economies, unlike France, the UK and the US, the rest of the economies studied have sustained manufacturing output shares over 20%.

In the economies where more detailed data was available (France, Germany, Korea, Taiwan, the UK and the US), the manufacturing sub-sectors that were identified as making the largest contributions to aggregate productivity growth include: transport equipment; computer, electronic and optical products; chemical products; and machinery and equipment. However, these are also among the manufacturing sub-sectors that saw their contribution to productivity growth diminish in the decade following the financial crisis. This is because of lower productivity growth rates, in combination with contractions in the size of these sub-sectors.

The contribution of these manufacturing sub-sectors to aggregate productivity growth is particularly large (more than 15% of overall productivity growth) in Germany (0.35 percentage points), Korea (1.14 percentage points) and Taiwan (0.97 percentage points), where manufacturing output accounts for over 20% of the total economy. In comparison, in France, the UK and the US, where manufacturing output shares are close to 10%, these sub-sectors contributed to less than 3% in the period of analysis (1998 to most updated data).

In Germany transport equipment is the manufacturing sub-sector that made the largest contribution to aggregate productivity growth, at 9% on average, in 1998–2017. This is the largest industry in Germany and the most innovative, accounting for around 20% of the total German industry revenue in 2021 and 35% of German business research and development (R&D) expenditure in 2018.[18] Germany has the highest concentration of all European automotive original equipment manufacturers (OEM) and tier supplier R&D centres. Small and medium-sized companies play a key role in Germany's automotive industry, with around 85% of the industry suppliers being medium-sized companies[19] (see economy-specific report).

In Korea the manufacture of computer, electronic and optical products is the sub-sector that made the largest contribution to aggregate productivity growth, at 10.2%, in 1998–2018. This industry represents around one-third of Korea's manufacturing value added. In 2015 Korea ranked fourth globally in the electronics industry in terms of output, behind only China, the US and Japan[20] (see economy-specific report).

In Taiwan the largest contributions are observed from these manufacturing industries. In 1998–2019 the manufacture of electronic parts and components, computers, electronic and optical products, and machinery and equipment, accounted for 31% of aggregate productivity growth. The semiconductor industry plays a key role in the Taiwanese and the world economy. In 2019 the semiconductor industry accounted for 28% of the total valued added of Taiwan's economy. Taiwan holds a 30% market share of the world's semiconductor industry, and its market share is even

[18] Germany Trade and Invest (2022). Automotive Industry; Germany Trade and Invest (2020). The Automotive Industry in Germany. Industry overview. Issue 2020/2021.
[19] Germany Trade and Invest (2020). The Automotive Industry in Germany. Industry overview. Issue 2020/2021.
[20] Lim, W. (2016). The Development of Korea's Electronics Industry During Its Formative Years (1966-1979). Ministry of Strategy and Finance.

larger in specific segments, such as semiconductor foundries (more than 70%) and integrated circuits (more than 50%). It is also ranked second, after the US, in chip design, with a global market share of more than 18%[21] (see economy-specific report).

Service activities are contributing to productivity growth through their increasing size and productivity dynamism. This is, however, not equal across all service activities and economies.

The shrinking of manufacturing has gone hand in hand with the expansion of service activities. Sectors that have seen their contribution to aggregate productivity growth increase include both activities with productivity levels that are above average (here classified as knowledge-intensive services),[22] such as financial and insurance activities and professional, scientific and technical activities, and more labour-intensive activities with productivity levels that are below average, such as wholesale and retail trade, human health and social work activities, and administrative and support services.

The expansion of above-average productivity service activities has led to positive allocation effects across five of the eight economies examined (second panel, Table 6). Taiwan, the UK and the US are the only exceptions, with negative, albeit small, allocation effects in the most knowledge-intensive services. As Figure 8 shows, these negative allocation effects arise mainly from the performance of the information and communication sector. This sector experienced reductions in its relative output prices in Taiwan, the UK and the US (see economy-specific reports), in addition to a small reduction in employment shares in the US (-0.56 percentage points between 1998 and 2017, Figure 7).

The information and communication sector is the service activity with the largest intra-industry growth effect in the UK and the US, which is explained by the fast productivity growth of this sector. Between 1998 and 2017 labour productivity of information and communication activities grew at an average annual rate of 9.7% in the UK and 6.5% in the US, which are far above the national averages (1.1% in the UK and 1.6% in the US) (Table 6). However, reductions in relative output prices have weakened the contribution of this sector to aggregate productivity growth (see economy-specific reports).

Nonetheless, across all economies, knowledge-intensive services as a whole made positive total contributions to aggregate productivity growth (Table 6). In the 1998–2017 period the largest contributions from knowledge-intensive services (in relative terms) are observed in the UK (53.8% of overall growth of 1.1%), the US (31.3% of overall growth of 1.6%), France (26.4% of overall growth of 2.2%) and Singapore (25.8% of overall growth of 3.1%, 2010–17). In the case of the UK and the US, this is driven mainly by both the professional, scientific and technical activities and the financial sector; in France it is mainly driven by professional, scientific and technical activities; and in Singapore it is driven by financial and insurance activities (Figure 9).

Professional, scientific and technical activities make up the knowledge-intensive service sector that has seen the largest expansion in most of the economies examined. The largest increase in employment shares from 1998 to 2017 is observed in Germany (2.3 percentage points), the UK

[21] Chang, M.F., Lin, C. and Shen, C.H. et al. (2021). The role of government policy in the building of a global semiconductor industry. *Nat. Electron. 4*, 230–233. https://doi.org/10.1038/s41928-021-00575-z

[22] Knowledge-intensive services include information and communication (J), financial and insurance activities (K), professional, scientific and technical activities (M) and education (P), with the exception of China, which includes financial intermediation, real estate, renting and business activities.

(2.0 percentage points) and France (1.7 percentage points) (Figure 8). This reflects the positive allocation effects estimated for this sector.

The financial and insurance sector expanded in China (5.4 in output shares and 0.4 in employment shares over the 1998–2017 period) and Singapore (3.3 in output shares and 0.5 in employment shares in 2010–17). In contrast, this sector has shrunk in the rest of the economies studied, particularly after the financial crisis of 2008 (Figure 8).

The reform of the Chinese financial system is likely to be contributing to this trend, and it is expected to accelerate in the coming years. Changes in the financial system have involved opening up to the participation of private and foreign banks and liberalising interest rates.[23]

In Singapore the government has continued to support a strong financial ecosystem. In 2017 the government launched the regional finance hub, "Asia's Infrastructure Exchange", with the aim of integrating infrastructure players along the entire value chain, including: multilateral banks, private financiers, lawyers, accountants, engineers and other professional services.[24]

The robust contribution of the financial and insurance sector to aggregate productivity growth is mainly explained by its fast productivity growth and productivity levels, which are higher than average. This sector experienced productivity growth that was faster than the national average across five of the eight economies analysed. The exceptions were China, Taiwan and Korea.

Among the service activities classified in this report as "other services",[25] administrative and support service activities (in the market sector) and human health and social work activities (predominantly non-market) saw the largest expansions, mainly during the 1998–2007 period. An increase in the size of administrative and support service activities is observed in Singapore (3.4 percentage points, 2010–17) and Germany (1.3 percentage points, 1998–2017) in terms of output, and in Taiwan (3.2 percentage points, 1998–2017) and Germany (3.1 percentage points, 1998–2017) in terms of employment.

The growth of the human health and social activities sector between 1998 and 2017 is more evident in Korea (2.0 percentage points increase in shares) and the UK (1.9 percentage points), in terms of output shares, and in Korea (5.4 percentage points) and Germany (3.0 percentage points) in terms of employment shares (Figure 8).

The wholesale and retail trade sector experienced a significant increase in its participation in employment in China (5.3 percentage points in 1998–2017) and in terms of output shares in Singapore (1.6 percentage points in 2010–17), while its relative size was reduced in the rest of the economies (Figure 8). Nonetheless, with the exception of the US and the UK, this sector is one of the main sources of aggregate productivity growth. Its contributions range from one-tenth of the overall productivity growth experienced in France (2.2% in 1998–2017) to around one-fifth of the productivity growth observed in Taiwan (2.4% in 1998–2017) and Singapore (3.1% in 2010–17).

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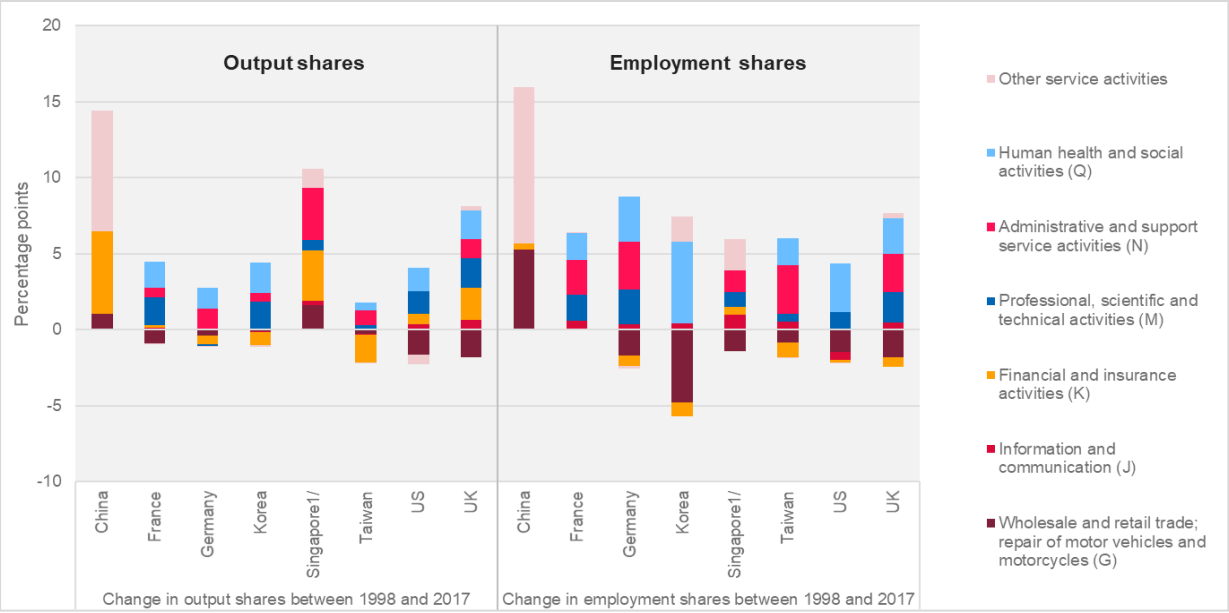
[23] Allen, F., Qian, J.Q. and Gu, X. (2017). An overview of China's financial system. *Annual Review of Financial Economics*, 9, 191–231.
[24] The World Bank (2019). Singapore. Overview.
[25] Other services include wholesale and retail (G), transportation and storage (H), accommodation and food service activities (I), real estate activities (L), administrative and support service activities (N), public administration and defence (O), human health and social work activities (Q), arts, entertainment and recreation (R) and other service activities (S, T), with the exception of China, which includes wholesale and retail (G), transportation and storage (H) and community, social and personal services.

As well as expanding, some service activities have seen their productivity improve, in some cases at rates above national averages (Table 6). Among the activities classified as “other services” in this report, wholesale and retail trade experienced productivity growth at a rate above the national average in Korea (5.5%, 2005–17) and Singapore (4.0%, 2010–17) (Table 3). Although the wholesale and retail trade sector tends to show productivity levels that are below the national average, in Singapore this is not the case (Table 2). Factors that may help to explain the remarkable performance of wholesale and retail trade in these economies include: leveraging the emergence of online retail channels; adopting digital technologies to improve consumer experiences; supporting skills development and digitalisation for internationalisation; and developing their infrastructure.[26] Productivity in the administrative and support service activities sector also grew faster than the aggregate, particularly in Singapore (7.6%, 2010–17) (Table 3).

Nonetheless, some of the higher-productivity service activities saw slower productivity growth rates in 2011–17 across several of the economies analysed. Mostly, these include financial and insurance activities; professional, scientific and technical activities; and information and communication sectors (see economy-specific reports).

FIGURE 8: CHANGE IN OUTPUT AND EMPLOYMENT SHARES BETWEEN 1998 AND 2017 (SELECTED SERVICE ACTIVITIES)



Note: 1/ For Singapore, the 2010–17 change is computed. For China, the data for financial and insurance activities refers to financial intermediation, real estate, renting and business activities.

Source: Authors’ computation, based on data from: APO Productivity Database 2020 Ver.1 (5 August 2020); OECD STAN Industrial Analysis (2020 ed.); Singapore Department of Statistics; Singapore Ministry of Trade and Industry; Manpower Research & Statistics Department; Taiwan Statistical Bureau; UK Office for National Statistics; US Bureau of Economic Analysis; and US Bureau of Labor Statistics.

[26] Infocomm Media Development Authority (2022). Wholesale trade. Industry digital plan; Retail Insight Network (2021). South Korea plans to inject $267m to support retail digitalisation; Research and markets (2021). Singapore Retail Sector - Growth, Trends, COVID-19 Impact, and Forecasts (2021 - 2026); USCS Korea (2021). Korea: retail industry.

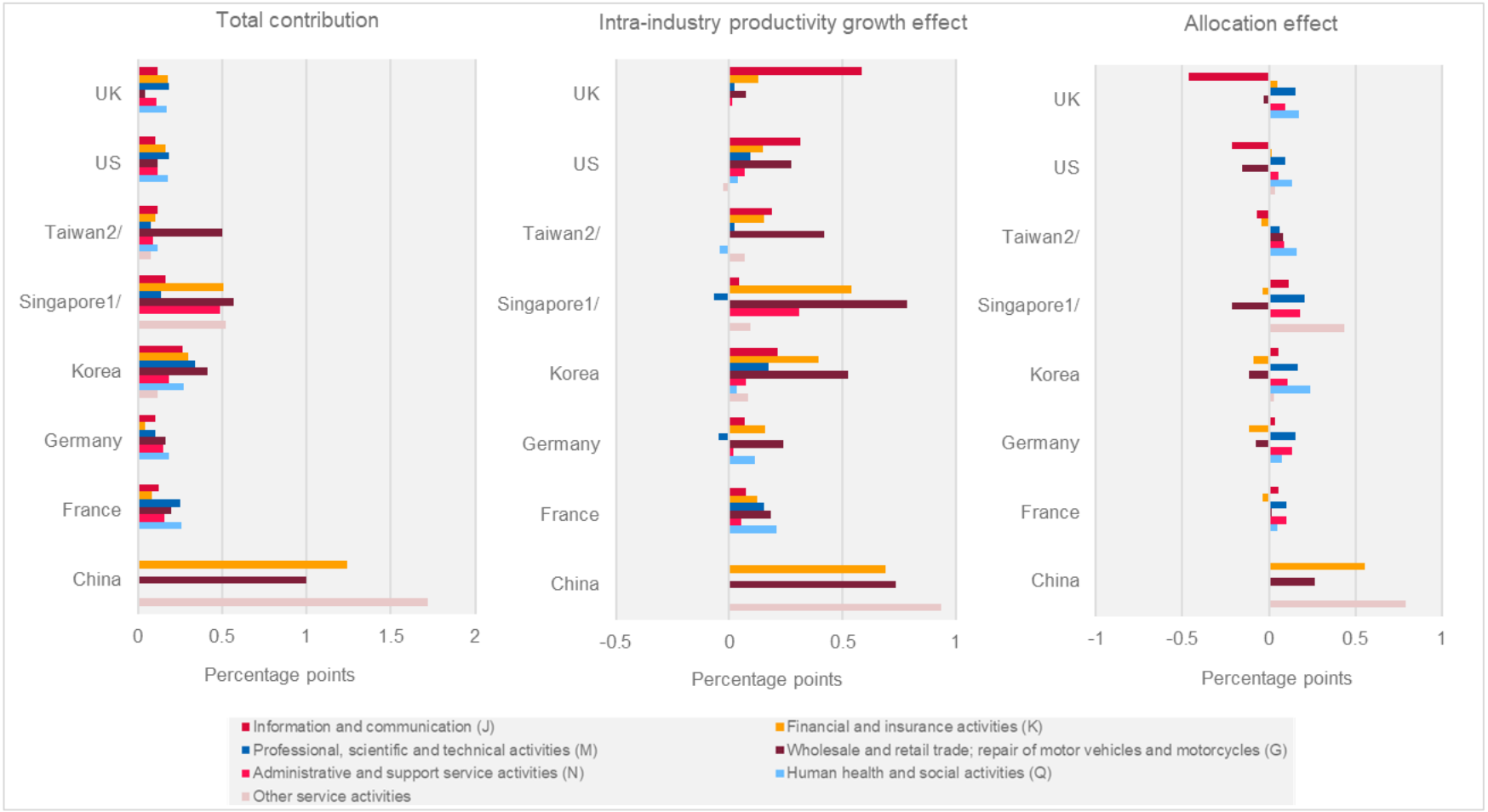
TABLE 6: CONTRIBUTION TO PRODUCTIVITY GROWTH BY ECONOMIC SECTOR, 1998–2017

Intra-industry productivity growth (annual average 1998–2017)								
Economic sector	China	France	Germany	Korea[1/]	Singapore[2/]	Taiwan[3/]	US	UK
Agriculture, forestry and fishing (A)	0.74	0.07	0.03	0.10	-0.11	N/A	0.03	0.04
Mining and quarrying (B)	0.51	0.01	0.01	0.00		0.00	0.06	-0.11
Utilities (D–E)	0.31	0.06	0.09	0.12		0.06	0.03	-0.03
Manufacturing (C)	2.66	0.35	0.63	1.61	1.50	1.82	0.51	0.56
Construction (F)	0.42	0.14	0.09	0.22	0.10	0.00	-0.04	-0.03
Knowledge-intensive services	0.69	0.47	0.23	0.50	0.52	0.44	0.55	0.64
Other services	2.23	1.29	0.82	1.52	1.34	0.76	0.60	-0.05
Whole economy	7.56	2.38	1.90	4.06	3.34	3.03	1.74	1.02
Allocation effect (annual average 1998–2017)								
Economic sector	China	France	Germany	Korea[1/]	Singapore[2/]	Taiwan[3/]	US	UK
Agriculture, forestry and fishing (A)	-0.25	-0.07	-0.03	-0.09	0.13	N/A	-0.04	-0.05
Mining and quarrying (B)	-0.17	-0.01	-0.01	0.00		-0.01	-0.02	0.07
Utilities (D–E)	0.00	-0.02	-0.05	-0.03		-0.04	-0.02	0.05
Manufacturing (C)	-0.12	-0.31	-0.21	-0.24	-1.02	-0.67	-0.55	-0.76
Construction (F)	0.16	0.02	-0.08	-0.03	-0.15	-0.04	0.12	0.17
Knowledge-intensive services	0.55	0.10	0.11	0.19	0.29	-0.23	-0.06	-0.05
Other services	1.21	0.08	0.09	0.39	0.54	0.38	0.39	0.63
Whole economy	1.34	-0.21	-0.18	0.19	-0.22	-0.61	-0.19	0.06
Total contribution to productivity growth (annual average 1998–2017)								
Economic sector	China	France	Germany	Korea[1/]	Singapore[2/]	Taiwan[3/]	US	UK
Agriculture, forestry and fishing (A)	0.49	0.00	0.01	0.00	0.01	N/A	0.00	-0.01
Mining and quarrying (B)	0.33	0.00	0.00	0.00		-0.01	0.04	-0.04
Utilities (D–E)	0.31	0.04	0.04	0.09		0.02	0.01	0.02
Manufacturing (C)	2.54	0.03	0.42	1.37	0.48	1.15	-0.04	-0.19
Construction (F)	0.59	0.16	0.01	0.19	-0.06	-0.04	0.07	0.14
Knowledge-intensive services	1.24	0.57	0.34	0.69	0.81	0.21	0.49	0.58
Other services	3.44	1.37	0.91	1.91	1.88	1.14	0.99	0.58
Whole economy	8.90	2.17	1.72	4.26	3.12	2.43	1.55	1.08

Note: Decomposition based on output per worker. Figures may not add to total because of rounding. [1/] For Korea, the 2005–17 annual average is computed. [2/] For Singapore, the 2010–17 annual average is computed and no disaggregated data is available for sectors A, B, D and E. [3/] Taiwan's decomposition of productivity growth excludes agriculture, forestry and fishing, and public administration and defence, because of data unavailability. Knowledge-intensive services include information and communication (J), financial and insurance activities (K), professional, scientific and technical activities (M) and education (P), with the exception of China, which includes financial intermediation, real estate, renting and business activities. Other services include wholesale and retail (G), transportation and storage (H), accommodation and food service activities (I), real estate activities (L), administrative and support service activities (N), public administration and defence (O), human health and social work activities (Q), arts, entertainment and recreation (R) and other service activities (S, T), with the exception of China, which includes wholesale and retail (G), transportation and storage (H) and community, social and personal services.

Source: Authors' computation based on data from: APO Productivity Database 2020 Ver.1 (5 August 2020); OECD STAN Industrial Analysis (2020 ed.); Singapore Department of Statistics; Singapore Ministry of Trade and Industry; Manpower Research & Statistics Department; Taiwan Statistical Bureau; UK Office for National Statistics; US Bureau of Economic Analysis; and US Bureau of Labor Statistics.

FIGURE 9: CONTRIBUTION TO AGGREGATE PRODUCTIVITY GROWTH, 1998–2017 (SELECTED SERVICE ACTIVITIES)



Note: Decomposition based on output per worker. 1/ For Singapore, the 2010–17 annual average is computed. 2/ Taiwan's decomposition of productivity growth excludes agriculture, forestry and fishing, and public administration and defence, because of data unavailability. For China, the data for financial and insurance activities refers to financial intermediation, real estate, renting and business activities; and the data for other service activities refers to community, social and personal services.

Source: Authors' computation, based on data from: APO Productivity Database 2020 Ver.1 (5 August 2020); OECD STAN Industrial Analysis (2020 ed.); Korea Productivity Center; Singapore Department of Statistics; Singapore Ministry of Trade and Industry; Manpower Research & Statistics Department; Taiwan Statistical Bureau; UK Office for National Statistics; US Bureau of Economic Analysis; and US Bureau of Labor Statistics.

Service activities where a large proportion of the output is derived from non-market transactions make a substantial contribution to aggregate productivity growth across the economies examined, particularly during the global financial crisis.

In the last two decades service activities where a large proportion of the output is derived from non-market transactions have made a substantial contribution to aggregate productivity growth across the economies examined. For the economies where data was available, Table 7 presents the contributions of three (predominantly) non-market services: public administration and defence and compulsory social security; education; and human health and social work activities.

The contributions of these sectors were particularly large during the global financial crisis and in those economies most impacted, such as France, Germany, the UK and the US, where the contribution of these sectors in 2008–10 accounted for a large proportion of the aggregate productivity growth seen in this period. Together, the contributions of these three sectors ranged from 46.3% in France to more than 100% in Germany, compensating for the decline in productivity experienced in other sectors.

From Table 4, the negative contribution of public administration and defence to US (-18.4%) and UK (-8.0%) aggregate productivity growth in the post-crisis period stands out. This is largely explained by declines in the size of this sector (see economy-specific reports).

In comparison, the contribution of human health and social work activities shows a steady increase. Considering the demographic trends in OECD member countries, including declining fertility rates, longer life expectancy and the resulting ageing population, this sector is expected to continue to increase its contribution to aggregate productivity growth in the coming decades because of its expansion.[27]

TABLE 7: CONTRIBUTION OF NON-MARKET SECTORS TO AGGREGATE PRODUCTIVITY GROWTH, 1998–2017

Economy	Public administration and defence; compulsory social security (O)			Education (P)			Human health and social work activities (Q)		
	Pre-crisis (1998–2007)	Crisis (2008–10)	Post-crisis (2011–17)	Pre-crisis (1998–2007)	Crisis (2008–10)	Post-crisis (2011–17)	Pre-crisis (1998–2007)	Crisis (2008–10)	Post-crisis (2011–17)
France	4.8%	14.8%	5.0%	4.0%	11.0%	5.4%	9.8%	20.5%	12.9%
Germany	1.5%	53.9%	4.3%	3.2%	38.1%	4.9%	7.0%	91.3%	10.7%
Korea	6.7%	6.2%	8.4%	6.7%	4.7%	3.7%	4.8%	5.4%	7.3%
Taiwan	N/A	N/A	N/A	N/A	N/A	-3.8%	3.6%	4.4%	2.4%
US	11.8%	32.7%	-18.4%	1.7%	6.5%	0.2%	8.6%	24.9%	8.3%
UK[1/]	5.2%	21.0%	-8.0%	11.6%	28.5%	-6.5%	15.1%	23.9%	6.9%

Note: Decomposition based on output per worker. [1/] Proportions for the UK for 2008–10 are computed over a negative growth rate (-0.5%).

Source: Authors' computation, based on data from: OECD STAN Industrial Analysis (2020 ed.); Singapore Department of Statistics; Singapore Ministry of Trade and Industry; Manpower Research & Statistics Department; Taiwan Statistical Bureau; UK Office for National Statistics; US Bureau of Economic Analysis; and US Bureau of Labor Statistics.

Real estate activities also contribute substantially to aggregate productivity growth, particularly in economies such as the UK and the US (see economy-specific reports). It is not unusual to exclude this sector from analyses, as rents from unproductive assets are included in this industry's output (imputed rents from owner-occupied dwellings are included in the value added of the sector); this

[27] OECD (2021). *Health at a Glance 2021: OECD Indicators*. OECD Publishing, Paris, https://doi.org/10.1787/ae3016b9-en.

boosts measured labour productivity above that observed in other sectors and can distort the sector's contribution to aggregate productivity.[28]

To isolate these measurement impacts from our aggregate productivity analysis, we also conducted decompositions, excluding the predominantly non-market services for the economies where sector disaggregated data was available. Excluding these sectors, overall productivity growth rates are smaller than those computed for the whole economy in China, France and the UK, while rates are larger in Germany, Korea, Taiwan and the US. The results of this decomposition are presented in Appendix III and the economy-specific reports.

Improving the measurement of public-sector productivity is a long-standing and complex challenge for national statistical offices. It can be difficult to identify the output of public services, as well as the input required to produce them and any changes over time. The absence of market transactions, and the fact that many government services are collective goods, which cannot be consumed individually, underlie many of the problems inherent in measuring the output of public services.

Traditionally, public sector output has been measured indirectly, by means of the output-equals-input convention. This approach, however, is not always considered satisfactory, as it does not take into account the possibility of productivity gains (government productivity growth is inherently zero). This method has increasingly been discarded in favour of other methods.[29]

In the UK, measures of productivity now include quality adjustments. Work to develop methods for measuring public service areas is ongoing and continues to follow the principles suggested by the Atkinson Review.[30] Different sectors, including health, education and some parts of public administration, are subject to direct measures of output. Examples include the use of a cost-weighted activity index to estimate the quantity of a service provided in education, such as the number of students in state schools.

[28] Riley, R., Rincon-Aznar, A. and Samek, L. (2018). Below the Aggregate: A Sectoral Account of the UK Productivity Puzzle. London: Economic Statistics Centre of Excellence. Office for National Statistics.
[29] Dunleavy, Patrick (2017). Public sector productivity: measurement challenges, performance information and prospects for improvement. *OECD Journal on Budgeting*, 17(1). pp. 1–28. ISSN 1608-7143. DOI: 10.1787/budget-17-5jfj7vb36p5c
[30] Atkinson, A. B. (2005). *The Atkinson review: final report. Measurement of government output and productivity for the national accounts.* Palgrave Macmillan, Basingstoke, England.

5. Concluding observations

This report provides insights into the extent to which sectoral dynamics help to explain recent trends in labour productivity growth across economies. We found that, although sluggish aggregate productivity growth after the global financial crisis of 2008 has been a dominant trend among the economies examined, China, Germany, Korea, Taiwan and Singapore have continued to outperform France, the United Kingdom and the United States. The report uncovers how differences in sectoral productivity growth and prevailing economic structures help to explain these differences.

Although deindustrialisation is a dominant trend among the economies analysed, manufacturing is the main sectoral driver of national productivity growth in the economies where manufacturing still accounts for more than 20% of national production, such as China, Germany, Korea and Taiwan.

As the findings of this report reveal, and similar studies have highlighted before,[31] manufacturing is a key source of national productivity growth, regardless of an economy's stage of development. Because of its capital-intensive nature, historically, the manufacturing sector has been the main driver of aggregate productivity growth.[32] Manufacturing tends to show productivity growth faster than the average of the whole economy, and thus, despite experiencing increases in the overall value added of the sector, manufacturing employment tends to grow at slower, or even negative, rates.

Increasing the participation of manufacturing in national economies has been included as a target in national and regional strategies. For instance, Singapore's 10-year "Manufacturing 2030" plan has the goal to grow manufacturing value added by 50% while maintaining a share of around 20% of the gross domestic product.[33] In 2012 the European Commission also set the target of increasing the manufacturing output share to 20% of the total economy by 2020.[34] However, this target has not yet been achieved.[35]

The shrinking of manufacturing has gone hand in hand with the expansion of service activities. Sectors that have seen their contribution to aggregate productivity growth increase include both high- and low-productivity activities.

Service sectors, such as financial services, information and communication, and professional, scientific and technical activities, show productivity levels and growth similar to – and in some economies even larger than – the manufacturing sector. The digitalisation of services is also making them more tradable and thus more exposed to international competition and productivity improvements.[36]

As the findings of this report show, service activities where a large proportion of the output is derived from non-market transactions, and which tend to be regarded as low production, have also made a substantial contribution to aggregate productivity growth across our sample of economies. The

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[31] Asian Productivity Organization, APO (2022). APO Productivity Outlook 2022. Manufacturing labor productivity: Trends and linkages. Tokyo: Asian Productivity Organization.
[32] Green, A., Hogarth, T., Kispeter, E., Owen, D. and Glover, P. (2016). *The future of productivity in manufacturing.* Institute for Employment Research, University of Warwick.
[33] Singapore Economic Development Board (2021). Singapore seeking frontier firms for 'Manufacturing 2030'.
[34] European Commission (2012). A Stronger European Industry for Growth and Economic Recovery. Industrial Policy Communication Update.
[35] World Bank (2022). World Bank national accounts data. Manufacturing, value added (% of GDP) – European Union.
[36] Baldwin, R. and Forslid, R. (2020). *Globotics and development: When manufacturing is jobless and services are tradable* (No. w26731). National Bureau of Economic Research.

contribution of human health and social work activities stands out because of its steady increase. Considering the demographic trends in the economies analysed, this sector is expected to continue to increase its contribution to aggregate productivity growth in the coming decades.

This report contributes to a better understanding of how productivity varies across sectors and economies and how these differences help to explain aggregate productivity gains and losses.

An effective policy to boost productivity growth needs to be grounded in a sound understanding of industry-specific characteristics, trends, and competition dynamics, and the interdependencies across industries.[37] Although productivity cannot grow at the same pace across all sectors, those with faster growth, usually tradable sectors, can drive up demand for non-tradable services and thus also have positive impacts on the wages of people working in those sectors.[38]

In a globalised economy, however, knowledge of sectoral differences across a national economy is not sufficient. Policy-makers also need to understand how sectoral productivity performance compares with other economies and to examine the role of public policy in these differences.

It is, however, important to recognise the limitations of productivity measures, particularly in predominantly non-market sectors, such as public administration and human health. Because productivity measures are based on value added measures, they suffer from similar limitations to those found in the measurement of gross domestic product (GDP). Such limitations have been discussed extensively in the academic literature in the last couple of decades, from how value added is mainly determined by market transactions, and the related undervaluing of non-market activities (such as unpaid domestic work and public services), to the failure to account for the environmental and social costs of economic activity.[39]

Human health and social work activities have increased their contribution to aggregate productivity growth in recent decades, and the shrinking of public administration has had negative impacts on UK and US aggregate productivity growth. However, we should question whether productivity is a useful metric to monitor the contribution of these sectors to society.

Although different methods have been developed to adjust the productivity measures of predominately non-market services to quality, these are far from perfect and tend to underestimate the non-market value of the contribution of these sectors to society.[40] Beyond measurement issues, productivity should not be confused with the efficiency with which these services are provided, as this could lead to drawing the wrong conclusions about, for example, the optimal size of a sector or the adequate wage levels.

Evidence also exists of the break-up of the relationship between productivity growth and wage increases. In the past two decades around two-thirds of OECD countries have experienced a break-up in this relationship; in addition, all but two OECD countries have also experienced increasing labour income inequality.[41]

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[37] Atkinson, R. (2021). Sectoral Policies to Drive Productivity Growth.
[38] Aubrey, T. (2021). Will boosting aggregate demand increase UK productivity growth? The Productivity Institute.
[39] See, for example: Mazzucato, M. (2018). *The value of everything: Making and taking in the global economy.* Hachette UK; Raworth, K. (2017). *Doughnut economics: seven ways to think like a 21st-century economist.* Chelsea Green Publishing; Stiglitz, J.E., Sen, A. and Fitoussi, J.P. (2010). *Mismeasuring our lives: Why GDP doesn't add up*. The New Press.
[40] Esquivel, V. (2019). Gender impacts of structural transformation. International Labour Organization. Technical Brief No. 2.
[41] OECD (2021). *OECD Compendium of Productivity Indicators*. OECD Publishing, Paris, https://doi.org/10.1787/f25cdb25-en.

The organisation of data based on economic activities has also shown limitations in capturing the blurring boundaries between industries.[42] The decrease in the share of manufacturing in advanced economies, is the result of not only less production but also changes in the classification systems. There has been an increase in the number of "services" categories, which has included the movement of manufacturing-related services out of manufacturing categories. In addition, some manufacturing companies have been reclassified as service firms, since the manufacturing share in their total output is falling.[43]

A government report estimated that up to 10% of the fall in manufacturing employment in the UK, between 1998 and 2006, may be due to this reclassification effect.[44] Although some manufacturing loss has been lost due to reclassification effect, the loss in the UK and US is still larger than other countries.

[42] López-Gómez, C. et al. (2017). *New industrial capabilities for new economic growth: a review of international policy approaches to strengthening value chain capabilities*. Report commissioned by the Department for Business, Energy and Industrial Strategy (BEIS).
[43] Hauge, J. and O'Sullivan, E. (2019). *Inside the black box of manufacturing: Conceptualising and counting manufacturing in the Economy.* Report prepared for the UK Department for Business, Energy and Industrial Strategy. Centre for Science, Technology and Innovation Policy.
[44] Chang (2014), cited in Hauge, J. and O'Sullivan, E. (2019). *Op. cit.*

Appendix I. Definitions of variables and data sources

Economy	Variable	Measure, units	Source
China	Labour (people)	Total employment, thousand persons	Asian Productivity Organization (APO) Productivity Database 2020 Ver.1 (5 August 2020)
China	Output (real values)	GDP at constant prices, billion yuan (2018 prices)	Asian Productivity Organization (APO) Productivity Database 2020 Ver.1 (5 August 2020)
China	Output (nominal values)	GDP at current prices, billion yuan	Asian Productivity Organization (APO) Productivity Database 2020 Ver.1 (5 August 2020)
France	Labour (hours)	Hours worked – total engaged (HRSN) – hours, millions	OECD STAN Industrial Analysis (2020 ed.)
France	Labour (people)	Number of persons engaged (total employment) (EMPN), persons, thousands	OECD STAN Industrial Analysis (2020 ed.)
France	Output (real values)	Value added, chained prices of the previous year (VKPY), euros, millions	OECD STAN Industrial Analysis (2020 ed.)
France	Output (nominal values)	Value added, current prices (VALU) – euros, millions	OECD STAN Industrial Analysis (2020 ed.)
Germany	Labour (hours)	Hours worked – total engaged (HRSN), hours, millions	OECD STAN Industrial Analysis (2020 ed.)
Germany	Labour (people)	Number of persons engaged (total employment) (EMPN), persons, thousands	OECD STAN Industrial Analysis (2020 ed.)
Germany	Output (real values)	Value added, chained prices of the previous year (VKPY), euros, millions	OECD STAN Industrial Analysis (2020 ed.)
Germany	Output (nominal values)	Value added, current prices (VALU) – euros, millions	OECD STAN Industrial Analysis (2020 ed.)
Korea	Labour (hours)	Total working hours, million hours	Korea Productivity Center, Productivity statistics.
Korea	Labour (people)	Number of persons engaged (total employment) (EMPN) – persons, thousands	OECD STAN Industrial Analysis (2020 ed.)
Korea	Output (real values)	VKPY: value added, chained prices of the previous year, won, millions	OECD STAN Industrial Analysis (2020 ed.)
Korea	Output (nominal values)	VALU: value added, current prices, won, millions	OECD STAN Industrial Analysis (2020 ed.)
Singapore	Labour (hours)	Average weekly total paid hours worked per employee, hours	Ministry of Manpower (2021). Statistical table: Hours worked
Singapore	Labour (people)	Total employment by industry, thousands	Ministry of Manpower (2021). Email communication
Singapore	Output (real values)	GVA in chained (2015) S$, million	Singapore Department of Statistics (2019). National Accounts. Gross Domestic Product In Chained (2015) Dollars, By Industry (SSIC 2020)
Singapore	Output (nominal values)	GVA at current prices, million S$	Singapore Department of Statistics (2021). National Accounts. Gross Domestic Product At Current Prices, By Industry (SSIC 2020)
Taiwan	Labour (hours)	Average monthly working hours (hours)	Taiwan Statistical Bureau (2021). Earnings exploration and information system
Taiwan	Labour (people)	Employee (persons), thousands	Taiwan Statistical Bureau (2021). Earnings exploration and information system
Taiwan	Output (real values)	Gross value added, chained (2016), million NT$	Taiwan Statistical Bureau (2021). National Accounts

Economy	Variable	Measure, units	Source
Taiwan	Output (nominal values)	Gross value added (current prices, million NT$)	Taiwan Statistical Bureau, National Accounts
United Kingdom	Labour (hours)	Hours worked, million	UK Office for National Statistics, Compendium of data related to labour productivity by low-level industry. January 2022 release.
United Kingdom	Labour (people)	Total jobs (thousands)	UK Office for National Statistics, Compendium of data related to labour productivity by low-level industry. January 2022 release.
United Kingdom	Output (real values)	GVA in pounds millions chained volume measure (constant prices)	UK Office for National Statistics, Compendium of data related to labour productivity by low-level industry. January 2022 release.
United Kingdom	Output (nominal values)	GVA in pounds millions at current prices	UK Office for National Statistics, Compendium of data related to labour productivity by low-level industry. January 2022 release.
United States	Labour (hours)	Hours, millions	US Bureau of Labor Statistics, Labor Productivity and Costs
United States	Labour (people)	Employment, total number of wage and salary workers, self-employed workers, and unpaid family workers, thousands	US Bureau of Labor Statistics, Labor Productivity and Costs
United States	Output (real values)	Value added by industry, millions of dollars	Bureau of Economic Analysis, GDP by Industry
United States	Output (nominal values)	Real value added by industry, millions of 2012 chain dollars	Bureau of Economic Analysis, GDP by Industry

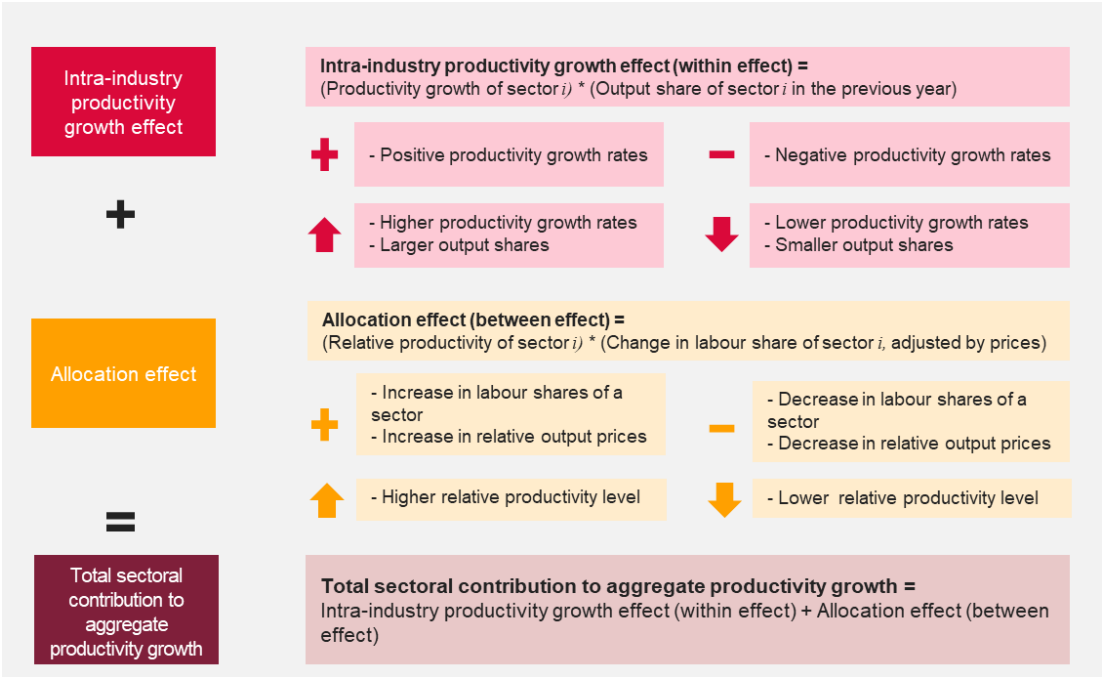
Appendix II. Decomposition of productivity growth

Economic sectors contribute disparately to aggregate productivity growth, depending on their productivity gains over time, as well as their relative weight in the total economy and relative productivity differences.

In order to understand the extent and nature of these contributions, we decompose the economy-wide labour productivity growth rates into sectoral contribution effects, as described in Tang and Wang:[45] (i) an intra-industry effect that captures the productivity growth of each economic sector, given the relative importance in the economy (within effect); and (ii) an allocation effect (between-industries effect) that captures the effects of changes in the relative size of sectors.

The intra-industry productivity growth effect of a given sector i takes positive (negative) values whenever the sector shows positive (negative) productivity growth. Its magnitude depends on the productivity growth rate and how large the sector is in relation to other sectors in the economy. Assuming that a sector i shows a productivity level above the national average, then the allocation effect will take positive (negative) values if the sector increases (decreases) in size. The relative size is determined by changes in labour shares and relative output prices of sector i. By changes in relative output prices, we mean how much the output prices in sector i change in relation to changes in the output prices of the whole economy.

FIGURE A.1: DECOMPOSITION OF SECTORAL CONTRIBUTION TO AGGREGATE PRODUCTIVITY GROWTH



Source: Authors, based on Tang and Wang (2004).

[45] Tang, J. and Wang, W. (2004). Sources of aggregate labour productivity growth in Canada and the United States. *Canadian Journal of Economics*, 37(2).

Appendix III. Decomposition of the "market economy"

Whole economy

Intra-industry growth effects

Economy	1998–2017
China	7.56
France	2.38
Germany	1.90
Korea	4.88
Taiwan	3.03
United States	1.74
United Kingdom	1.02

Allocation effects

Economy	1998–2017
China	1.34
France	-0.21
Germany	-0.18
Korea	-0.17
Taiwan	-0.53
United States	-0.19
United Kingdom	0.06

Total aggregate productivity growth

Economy	1998–2017
China	8.90
France	2.17
Germany	1.72
Korea	5.06
Taiwan	2.68
United States	1.55
United Kingdom	1.08

Market economy

Intra-industry growth effects

Economy	1998–2017
China (only real estate excluded)	7.66
France	2.15
Germany	2.01
Korea	5.49
Taiwan	3.62
United States	2.22
United Kingdom	1.79

Allocation effects

Economy	1998–2017
China (only real estate excluded)	0.93
France	-0.19
Germany	-0.16
Korea	-0.45
Taiwan	-0.32
United States	-0.44
United Kingdom	-1.04

Total aggregate productivity growth

Economy	1998–2017
China (only real estate excluded)	8.59
France	1.96
Germany	1.86
Korea	5.25
Taiwan	3.30
United States	1.77
United Kingdom	0.75

Source: Authors' computation, based on data from: APO Productivity Database 2020 Ver.1 (5 August 2020); OECD STAN Industrial Analysis (2020 ed.); Korea Productivity Center; Singapore Department of Statistics; Singapore Ministry of Trade and Industry; Manpower Research & Statistics Department; Taiwan Statistical Bureau; UK Office for National Statistics; US Bureau of Economic Analysis; and US Bureau of Labor Statistics.

UNIVERSITY OF CAMBRIDGE
Department of Engineering

IfM MANAGEMENT TECHNOLOGY POLICY

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