Productivity and structural change: Cross-country evidence

*Ana Rincon-Aznar[c] , Jennifer Castaneda-Navarrete[2] and Carlos Lopez-Gomez[2]

[1] National Institute of Economic and Social Research (London)

[2] Policy Links Unit, IFM Engage, University of Cambridge

Abstract

This paper compares the labour productivity performance for eight large economies at different stages of development, which account for over half of the world's economic output: China, France, Germany, the Republic of Korea, Taiwan, Singapore, the United Kingdom and the United States. We describe the main features of their overall labour productivity growth performance during the period 1998 to 2017, and then look at what extent their industry make-up and sectoral dynamics explain the diversity in cross-country experiences in a period of stalling productivity growth globally.

*Corresponding author: a.rincon@niesr.ac.k, The National Institute of Economic and Social Research, London.

Acknowledgements & Disclaimers

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

1. Introduction

Since the global financial crisis of 2008 sluggish aggregate productivity growth has been a dominant trend in the developed world. At the same time, emerging economies have also seen a deterioration in the rate of productivity growth after decades of fast growth and catching-up to income levels of industrialised economies. The experiences across countries are diverse, but many suggest we are in an era of secular stagnation (Gordon, 2015).

As a major determinant of material prosperity, understanding the slowing trend growth of labour productivity is of prime concern for policy makers many countries. The literature suggests a number of factors that may explain the global productivity slowdown, which include: the decrease of international trade flows after the global financial crisis of 2008, a declining technological progress and slower efficiency gains from technology adoption, and an ageing workforce (Dieppe, 2021). However, the growth patterns across countries are likely respond to a mix of domestic and international factors.

In this paper we draw from cross-country and industry-level data to look at labour productivity performance in a sample of global countries at different levels of development and with different structural features. We investigate in detail how the performance of different sectors contributes to understand what we see at an aggregate level, shedding light on each country's productivity weaknesses and strengths.

We map labour productivity developments for a few of a large industrialised Western and Asian economies some of which had industrial development at the core of their development strategies. We look at France, the United Kingdom and the United States where productivity growth deteriorated markedly since the Great Recession, and at Germany which recovered faster from the global financial crisis. We then look at a group of Asian countries, both emerging and more advanced (China, South Korea, Taiwan and Singapore), that while having enjoyed decades of strong labour productivity growth and economic catch-up, have not been immune to the global slowdown.

The main period of analysis 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, more recent data is included for specific countries. We measure the extent to which changes in the composition of economic output explain the phenomenon of declining productivity that we observe in many countries. Many have argued that the slowdown we observe is simply the reflection of the reallocation of labour towards labour-intensive lower productivity service activities. But there are also likely to be a myriad of factors that determinate an unequal productivity within sectors. A full investigation of the role played by

the factors of production and technological change in each sectors' labour and aggregate labour productivity is however beyond the scope of this study.

Our paper is structured as follows. In Section 2 we describe the main labour productivity growth trends across countries in the years that follow the 2008 financial crisis both at the aggregate and at the industry level; in Section 3 we provide an overview of patterns of structural change during this period; in Section 4 we describe the results of decomposing each country's rate of labour productivity into within-industry effects and allocation effects and compute the sectoral contributions to total labour productivity growth. Section 5 offers a more detailed view on country-specific results and Section 6 concludes. In the Appendix I we include information on the data sources used for each country and Appendix II-IV we include further analysis and results.

2. Labour productivity

2.1 Aggregate trends

Since the financial crisis, global labour productivity growth decelerated from an average rate of 2.0% in 1998–2007 to a rate of 1.6% in 2008–19.[1] However, the disparities across economies are stark. Figure 1 illustrates the evolution of total GDP per worker of our sample of economies, for the period of 1997–2017. We use a measure of GDP per worker rather than hours as we do not have comparable measures of hours worked for all countries (e.g. China). Admittedly, measures of labour productivity that consider the total number of workers as measures of labour input will disregard the impact of differences in average hours worked across countries. For some of the country-specific analyses we use GDP per hour as hour measure of labour productivity.

Bearing in mind this caveat, Singapore stands out with the highest level of output per worker in 2017, at USD$ 124,967[2], followed by the US with an average of USD$ 107,705. Above China, the UK is the country with the lowest level of productivity of those shown here.

Because of its large workforce and fast productivity growth, China is now the second-largest economy in the world after the United States.[3] China saw the fastest labour productivity growth with 8.3% annual rate of change during the 1998–2017 period. Despite this fast growth, productivity levels in China (at US$21,706 output per worker in 2017) remain significantly below those of developed economies. China's overall productivity level is almost one fifth of that in the US and just under one-third that in the UK.

Figure 1 also shows remarkable performance achieving of South Korea which had the second-highest rate of labour productivity growth in our sample (5.1% on average for the period 1998-2017), only behind China. In 1998 South Korea's output per worker was around half of that observed in the UK; by 2017 it was already 2% higher than the UK (Figure 1). When we look at the whole twenty years, the UK is the country with the lowest average rate of labour productivity growth, about 1.1%. This is despite the UK having enjoyed a productivity boom in the years leading up to the recession when it grew at similar or above

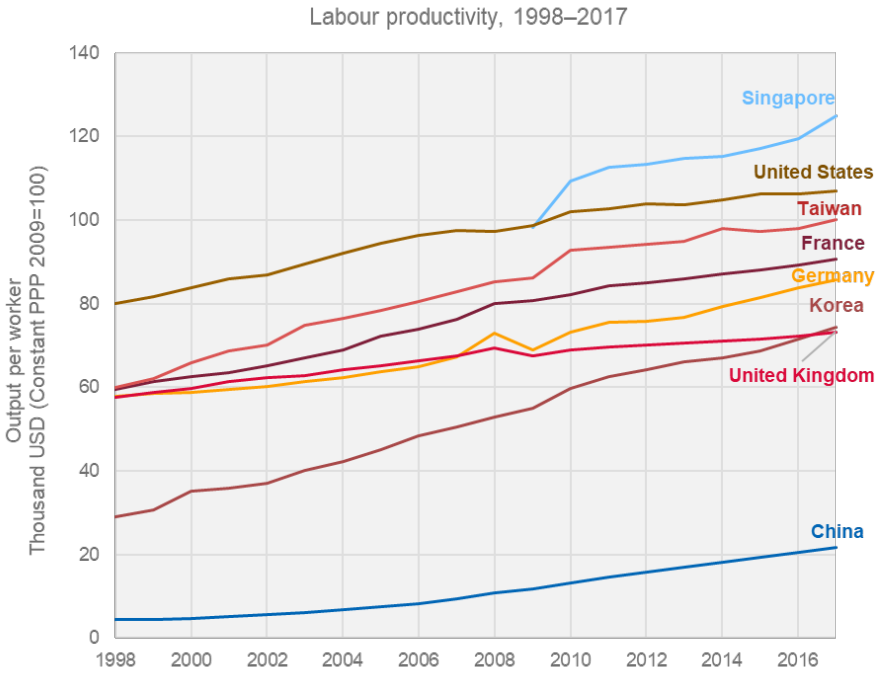
[1] World Bank Development Indicators and ILOSTAT.

[2] Constant purchasing power parity (PPP), 2009 = 100.

[3] UNCTAD (2022). China's structural transformation. What can developing countries learn? New York: United Nations.

rates than the US (Timmer et al, 2010). Below we examine in more detail differences in labour productivity over time.

Figure 1: *Whole economy GDP per worker, 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 period of 2010–17 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.

Following the financial crisis of 2008, productivity growth has indeed slowed down across all of the economies examined here. China is the only country to have seen a rise in the growth rate of GDP per worker throughout the crisis years, rising from an average of 9.5% in 1998–2007 to 10.5% in 2008–10. But this was more modest than in previous years. Korea and Taiwan continued to experience robust positive productivity growth rates during the crisis, but these have been lower than those observed during the pre-crisis period. France and the US saw a clear productivity growth deceleration.

The UK was the only country in our sample for which labour productivity growth (again measured as output per worker) turned negative during the crisis period (Table 1). UK 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). This phenomenon is not exclusive

to the UK as other countries have also experienced unusually weak productivity growth, but it seems to have affected the UK more severely (Riley et al., 2018). The weakness of productivity growth has come to be known as the 'UK productivity puzzle'.

While Germany's rate of productivity growth also fell in the years following the financial crisis, productivity levels in this country have remained high. Germany's labour productivity collapse significantly during the global financial crisis of 2008, but to a lesser extent than in the UK. Productivity growth decelerated from 1.7% in 1998–2007 to 0.3% in 2008–10; however, unlike the UK, Germany's productivity seems to have recovered its dynamism in the decade that followed the crisis, achieving a 2.3% per year compared to the decade before the crisis, when it was 1.7%. Factors likely to explain the recovery include a strengthening of its 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 (Marin, 2018).

Table 1. *Labour productivity growth rates, 1998–2017*

Economy	Whole period of analysis (1998–2017)	Sub-periods		
		(1) Pre-crisis (1998–2007)	(2) Crisis (2008–10)	(3) Post-crisis (2011–17)
China	8.9%	9.5%	10.5%	7.3%
Korea	5.1%	6.2%	5.7%	3.2%
Singapore	3.1%[1/]	N/A	N/A	1.9%
Taiwan	2.7%	3.8%	2.5%	1.1%
France	2.2%	2.8%	1.8%	1.4%
Germany	1.7%	1.7%	0.3%	2.3%
US	1.6%	2.1%	1.8%	0.7%
UK	1.1%	1.7%	-0.5%	0.9%

Note: Economies are ranked from the highest average growth rate in the whole period of analysis to the lowest. N/A, not available. [1/] The period of 2010–17 for Singapore. Labour productivity measured as output per worker.

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

2.2. Sectoral growth trends

Table 2 below shows labour productivity growth rates by broad industry group for the whole period 1998-2017 for each country of the sample. We consider the market and non-market economy (this includes about nineteen industries equivalent to the 1- digit NACE classification, but some figures are missing to the lack of data in some countries). We highlight in green shades the positive labour productivity growth rates and in red shades those that are negative. A number of key findings emerge from the analysis of this table, where we describe the performance of primary industries, manufacturing and services industries.

- Labour productivity in the agricultural sector in China grew at a rate closer to 7% per annum during these twenty years, and the mining sector grew at rates closer to 12%. The lowest rate of labour productivity growth is observed in the US agricultural sector (just under 3% on average), while the UK mining sector experienced negative labour productivity growth rates (-5.2%).

- Output per worker in China's manufacturing sector grew at 8.3% on average per year, only slightly below than that for the total economy.
- South Korea, Taiwan and Singapore's manufacturing sectors productivity grew at rates ranging between 6-7% per annum, and US and UK manufacturing saw also healthy labour productivity growth of around 4% per year. The lowest labour productivity growth rate of all manufacturing sectors is seen in France (around 2.5% per year).
- Figure 2 below illustrates the differences in performance of the various manufacturing sectors relative to the total economy and highlights changes over time. We see a faster labour productivity growth in manufacturing compared to the total economy in the majority of countries, except in China and South Korea where the average labour productivity growth rate is in line with that of the total economy. The faster labour productivity growth is more clearly in the case of the UK, Singapore and Taiwan. Across sub-period we see that the rate of growth of manufacturing productivity has slowed down in Germany over time as well as in the US.
- The worse performing construction sectors were that of the US and the UK, where the average labour productivity growth was negative during this period. Labour productivity improvements in China's and South Korea's construction sectors were also remarkable (growing at 7% and 4% respectively per year).
- We see that the lowest productivity growth rate of all the the electricity and gas and water supply and waste management sectors was that for the UK (0.7% and -2.6% respectively on average). However, productivity data for the utilities sector is more scattered, so a full comparison across countries was not always possible.
- Across services, we see there is significant variation in labour productivity growth performance across countries. We first look knowledge service activities[4] which include financial services, information and communication activities, as well as professional, scientific and technical activities. In the financial sector the greatest labour productivity growth rates were observed in China and Singapore, with average rates of 6.7% and 4.5% respectively. The financial sectors of the Western economies grew at rates of around 2-3% on average each year.
- Labour productivity growth in the professional, scientific, and technical sector was modest everywhere, but it grew more rapidly in South Korea (with an average rate of 3.2% per year) and in France (with an average rate of 2.2%).
- UK stands out as the country with the greatest labour productivity growth rate in the information and communication activities sector, with an average rate of 9.7%, followed by the US with an average rate of 6.5%, and Taiwan with an average rate of 5%. The rest of the countries' performance was noticeably inferior.
- In other service activities, which includes less-knowledge intensive sectors, the picture is more mixed. Output per hour grew faster in the wholesale and retail sector of China (7.1%), South Korea (5.5%) and Singapore (4%). The slowest growth rate is that of the UK, with just below 1% on average. We see a similar picture for the transportation and storage sector, with China growing at a rate of 7.3% per year and South Korea at 4.4%. In this case Singapore performed significantly worse than its Asian counterparts. The US and the UK transport and storage sectors were the ones

[4] Following Eurostat classification.

that fared less well during this period, with average growth rates of 0.6% and 0.1% per year.

- Labour productivity in the accommodation and food sector generally grew at rates below 2% per year with the exception of Taiwan, where this was 4.1%. It was negative in Taiwan (-1.8%) and the UK (-0.2%).
- Labour productivity growth was poor in the administrative and support activities sector of most countries, except in Singapore (7.6% per annum) and South Korea (2.4% per annum). The arts, recreation and entertainment sector present a similar case, with only productivity in South Korea growing at a robust rate of close to 5% per year.
- For predominantly non-market activities, the comparison appears more problematic due to the differences in methodologies to the measurement of output and productivity. Bearing in mind the limitations in establishing meaningful comparisons, these data show relatively lower (or even frequently negative) rates of labour productivity growth in these sectors.

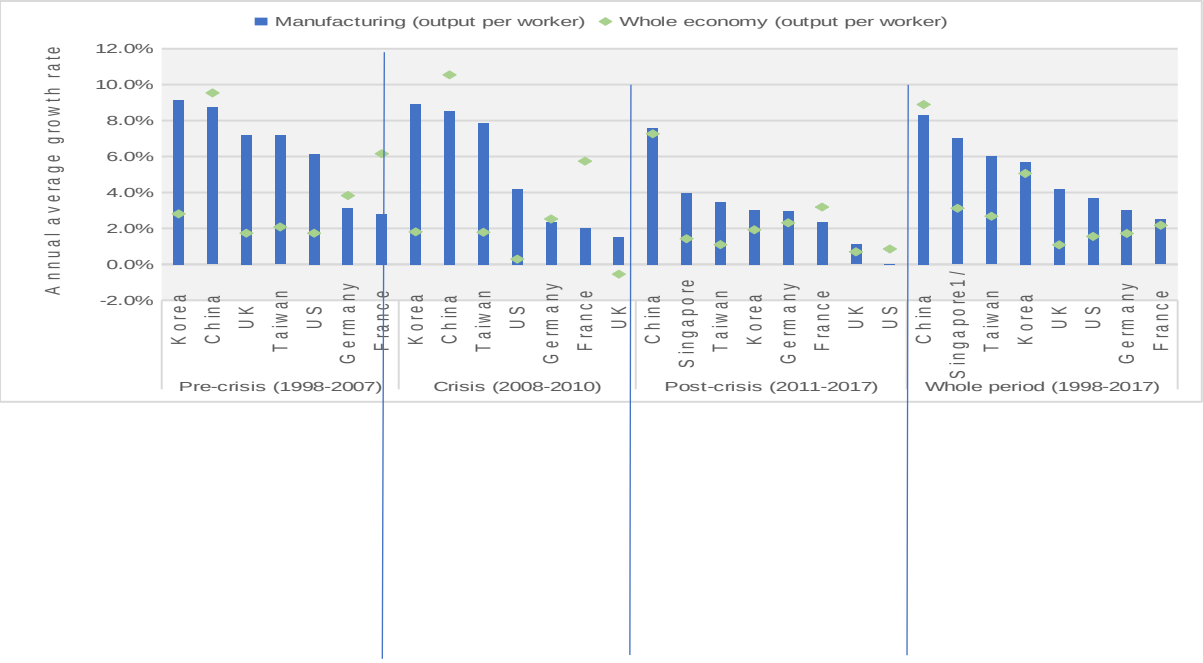
Table 2: Labour productivity growth rates by broad sector, 1998–2017.

Economic sectors		Output per person (average annual growth rate, 1998–2017)							
		China	France	Germany	Korea [1/]	Singapore [2/]	Taiwan [3/]	US	UK
Production	Agriculture, forestry and fishing (A)	6.8%	3.3%	3.3%	4.2%	N/A	N/A	2.9%	4.7%
	Mining and quarrying (B)	11.6%	4.8%	4.2%	2.2%	N/A	1.1%	2.6%	-5.2%
	Manufacturing (C)	8.3%	2.5%	3.0%	5.7%	7.0%	6.0%	3.7%	4.2%
	Electricity, gas, steam and air conditioning supply (D)	N/A	2.4%	3.9%	4.5%	N/A	2.8%	N/A	0.7%
	Water supply; sewerage, waste management and remediation activities (E)	N/A	2.0%	2.7%	N/A	N/A	2.5%	N/A	-2.6%
	Construction (F)	6.9%	2.7%	2.1%	4.0%	1.7%	-0.2%	-0.9%	-0.3%
Knowledge-intensive	Information and communication (J)	N/A	1.4%	1.6%	1.6%	1.1%	5.0%	6.5%	9.7%
	Financial and insurance activities (K)	6.7%	3.0%	2.9%	3.7%	4.5%	2.0%	2.3%	2.0%
	Professional, scientific and technical activities (M)	N/A	2.2%	-0.7%	3.2%	-1.0%	1.0%	1.4%	0.4%
	Education (P)	N/A	2.3%	1.1%	3.9%	N/A	1.2%	-0.4%	-1.8%
Other services	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%
	Transportation and storage (H)	7.3%	2.4%	1.9%	4.4%	1.0%	2.7%	0.6%	0.1%
	Accommodation and food service activities (I)	N/A	2.1%	1.2%	4.1%	1.6%	-1.8%	0.0%	-0.2%
	Real estate activities (L)	N/A	3.4%	1.2%	2.4%	0.8%	2.3%	1.9%	-1.5%
	Administrative and support service activities (N)	N/A	1.0%	0.4%	2.4%	7.6%	0.4%	N/A	0.2%
	Public administration and defence; compulsory social security (O)	N/A	2.6%	2.7%	4.3%	N/A	N/A	0.0%	1.7%
	Human health and social activities (Q)	N/A	2.7%	1.6%	-0.4%	N/A	-1.2%	0.6%	0.0%
	Arts, entertainment and recreation (R)	N/A	2.0%	1.0%	4.7%	N/A	0.6%	0.6%	0.0%
	Activities of households (T)	N/A	0.1%	1.5%	N/A	N/A	N/A	N/A	4.6%
	Other service activities	6.9%	1.8%	0.8%	N/A	0.9%	2.4%	-1.2%	-1.3%
Whole economy		**8.9%**	**2.2%**	**1.7%**	**4.2%**	**3.1%**	**2.7%**	**1.6%**	**1.1%**

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 total productivity excludes sectors A and O.

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 2: 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.

3. Structural change

The previous section has revealed which were the most and least dynamic sectors in terms of labour productivity during the period 1997-2017, across all the various countries. Because of differences in their relative (and changing) size, they make uneven contributions to overall productivity patterns. A look at countries' economic structures can tell us which are the sectors that make the greatest contribution to aggregate productivity improvements.

The structural shift in economic activity towards the service sector is often identified as the primary reason for the slowdown in the productivity performance of advanced countries (Duernecker et al., 2017). It is argued that most activities in the service sector may offer less potential for productivity growth compared to manufacturing activities, as often production processes in the service sectors are usually more labour-intensive and may be more sensitive to technological substitution.

Table 3 contains the countries' output and employment shares of broad industry groups (for the most recent years available). They represent the distribution of output (in nominal terms) and employment across the primary sector, construction and utilities, the manufacturing and services sectors. Figures 3 and 4 illustrate the how these shares have varied throughout the years.

We see that that China has the largest agricultural sector, accounting for 7.5% and 25% of output and workforce. In the rest of the countries the agriculture sector represents less than 2% of the total economy in terms of output (and less than 3% in terms of employment). It is a little higher in South Korea, where it still represents around 5% of total employment. In all countries the agriculture sectors have shrunk, and in China by almost 10 percentage points in terms of output and almost 25 percentage points in terms of employment during the period of twenty years. To give a sense of scale, around 150 million workers left the farms in China between 1998 and 2018.

China's is the only manufacturing sector that has seen an increase in its relative size in these, twenty years while the manufacturing has shrunk in most of the other economies. In the case of the US, UK and France it has fallen between 5 and 6 percentage points in employment terms. In these countries manufacturing represents close to 10% of the total economy's employment. In the case of Germany, the share of manufacturing in total employment has remained stable at around 22%.

The services sector has experienced a substantial expansion everywhere. In these twenty years, the service sector has expanded between 5 and 8 percentage points in the share of employment in most countries, and by more than 15 percentage points in South Korea and China.

We see substantial differences in the composition of the service sectors across countries (Figure 5). The financial sector has experienced the greatest growth in China, Singapore and the UK, but mainly in terms of output. Other service activities (which includes community, social and personal services) have experienced an impressive growth in China, increasing by 8 percentage points in terms of output and 12 percentage points in employment.

The professional, scientific, and technical activities sector has expanded fastest in the UK, the US, as well as France in Germany and also Singapore. This is also the case for the administrative and support services activities. The wholesale and retail sector now represent a smaller share of total employment than it did in the late 90s, in all countries except China. The share of employment accounted for by the health and social work sector has increased in the majority of countries.

Table 3 .Employment and output shares across countries, 2019.

	*Output shares (2019)**							
	China	South Korea	Singapore	Taiwan	United States	United Kingdom	Germany	France
Agriculture, forestry and fishing	7.50%	1.90%	1.30%		0.82%	0.68%	0.90%	1.70%
Mining and quarrying	2.60%	0.10%	.	0.81%	1.44%	1.07%	0.10%	0.10%
Manufacturing	29.30%	29.10%	21.30%	35.17%	10.94%	9.93%	22.80%	11.20%
Electricity, gas and water supply; sewerage & waste.	2.00%	2.00%	.	0.41%	1.56%	2.70%	2.80%	2.40%
Construction	6.90%	5.90%	4.00%	5.79%	4.16%	6.40%	4.70%	5.60%
Services	51.70%	60.90%	73.50%	58.20%	81.04%	79.20%	68.70%	78.90%
	*Employment shares (2019)**							
	China	South Korea	Singapore	Taiwan	United States	United Kingdom	Germany	France
Agriculture, forestry and fishing	25.50%	5.00%	0.70%	.	2.72%	1.12%	1.40%	2.70%
Mining and quarrying	0.70%	0.10%	.	0.90%	0.42%	0.18%	0.10%	0.10%
Manufacturing	18.40%	16.80%	12.80%	41.22%	7.93%	7.76%	17.20%	9.30%
Electricity, gas and water supply; sewerage & waste.	0.50%	0.70%	.	0.41%	0.33%	1.00%	1.20%	1.10%
Construction	8.80%	7.60%	12.10%	8.21%	5.55%	6.62%	5.60%	6.20%
Services	46.00%	69.80%	74.30%	49.47%	83.05%	83.30%	74.40%	80.80%

Notes: Total shares may not add up exactly to 100 due to rounding; * Figures refer to 2018 for China and South Korea, for 2017 in the case of Germany, and France. The agricultural sector for Singapore here also comprises the figures for Mining.

Figure 3. Change in outputs shares across broad sectors: Differences in output shares between 1998 and 2018)

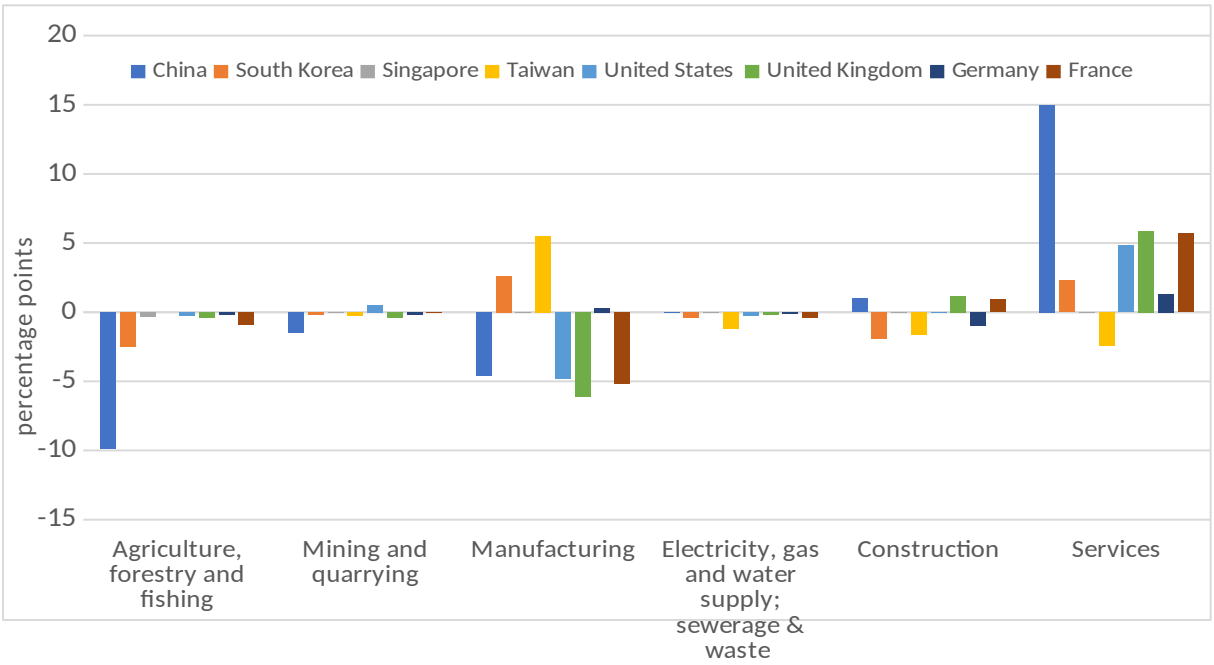


Figure 4. Change in employment shares across broad sectors Differences in employment shares between 1998 and 2018)

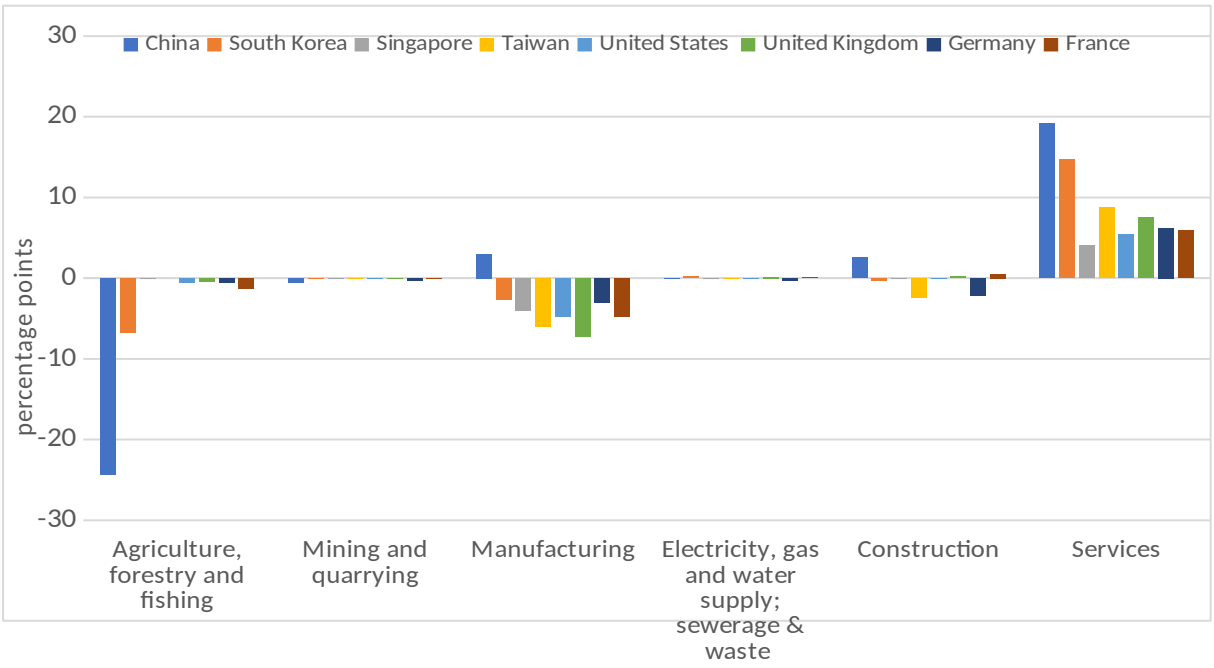
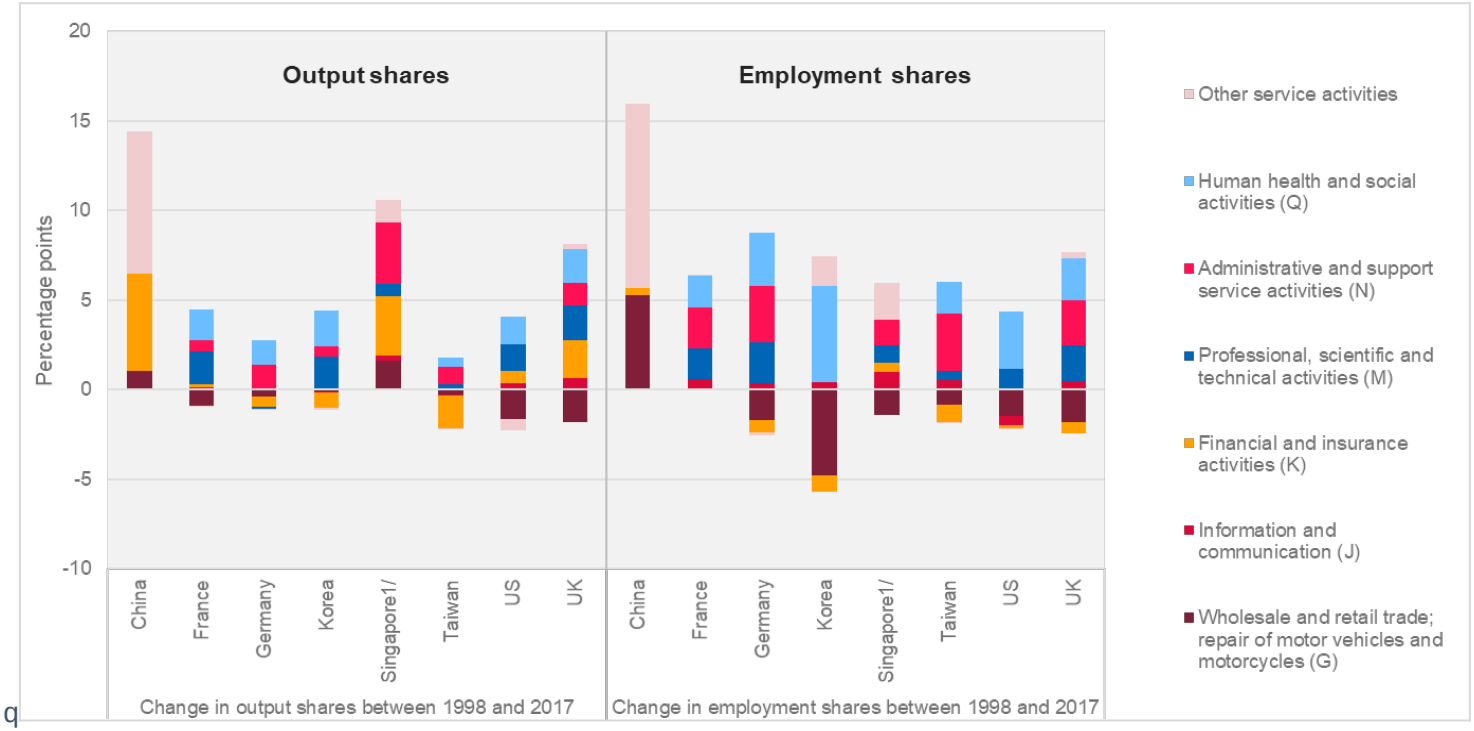


Figure 5. Change in output and employment shares services sectors, 1998-2017.



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.

4. A sectoral decomposition of aggregate labour productivity growth, within and between effects.

4.1 Applying Tang and Wang's methodology

The rate at which national labour productivity grows is the result of the labour productivity that takes place within different industrial sectors, as well as the reallocation of resources across the economy due to ongoing structural change. We have seen in the previous section how deindustrialisation has been a feature of most advanced economies in the last twenty years, while others like China we continue to see a transition from agriculture to industry and services.

In order to understand the extent to which the various sectors help to explain recent trends in national labour productivity growth across our sample of economies, we have decomposed labour productivity growth rates into two main sub-components, a 'within (intra-industry) effect' and a 'between (allocation) effect'. This follows the methodology by Tang and Wang (2004).

$$g_t = \underbrace{g_i \sum_i \frac{Y_{i-1}}{Y_{t-1}}}_{within\ effect\ (1)} + \underbrace{\sum_i (1+g_i)\frac{Z_{i-1}}{Z_{t-1}}\left(p_i l_i - p_{i-1} l_{i-1}\right)}_{between\ effect\ (2)} \quad (1)$$

Where g_t denotes the aggregate growth in labour productivity measured on the basis of gross value added, g_i is the labour productivity growth of sector i at time t; Z_i is the productivity level in period t; $p_i$is the relative price of sector i to economy-wide prices, and l_i is sector i's share in total employment.

The intra-industry growth effect captures the contribution made by each sector to the overall labour productivity growth rate, given by the product of each sectors' productivity growth rate and its relative size. The between or allocation effect in contrast captures the contribution of sectors to aggregate productivity growth due to changes in their relative size over time, given their relative productivity levels. The total contribution of a sector i to national productivity growth is given by the sum of the intra-industry growth effect and the allocation effect. And the sum of the total sectoral contributions adds up to the aggregate labour productivity rate of a particular year (or sub-period).

The Tang and Wang (2004) methodology introduces the role of changes in industry output prices and recognises that a sector's contributions to aggregate productivity growth is determined by changes in its relative size. This can be due to either a change in a sector's share of total employment or its real output prices, or both. For instance, an increase in a sector's prices compared with the economy-wide price level will increase the sector's contribution to aggregate labour productivity growth, even in the absence of a shift in labour inputs. In this decomposition these effects are combined and any conclusions we draw will be based on prior evidence. More recently, Diewert (2015) re-work this methodology adding

extra terms that separate the effect of real price changes from changes to labour input shares when decomposing the rate of aggregate labour productivity growth for the US.

In Appendix II we show more intuitively the cases in which the within and between effects will be positive and or negative. The within effect *will be positive always when an industry experiences positive labour productivity growth*, and negative when an industry experiences negative labour productivity growth. The effect will be larger depending on the magnitude of the increase (or decrease) relative to the overall size of the sector. *Therefore*, labour productivity growth rates in larger industries will have a larger impact on aggregate labour productivity growth than the same growth in smaller industries.

The allocation effect of a single industry will be positive always when an industry increases and will always be negative when an industry shrinks. The size of the effect will be proportional to its productivity relative level. This indicates for example that if a high productivity industry loses market share to a low productivity industry, the overall between effect will be to decrease aggregate productivity. A positive allocation effect suggests that overall resources are moving towards the most productive sectors, while a negative between effect is indicative of reallocation towards less productive uses and this results in a decrease on total productivity growth.

Table 4 shows the results of decomposing the total economies' labour productivity growth rate into a 'within effect' and a 'between effect', for the whole period 1998-2017. We distinguish the contribution made by broad industry groups. We group the services activities in two distinct groups: 'knowledge-intensive' activities and 'less-knowledge-intensive' activities to facilitate comparisons.

We find that manufacturing remains a key source of aggregate productivity growth especially in the economies with a relatively large manufacturing base. For these economies, such as China, Korea and Taiwan and also Germany the contribution of manufacturing accounted for approximately between one third (in China, in Germany) to half (in Taiwan) of the national productivity growth observed each year (on average during the period of 1998–2017, see Table 4). When we look at the 'within' and 'between' effects we see that that positive contribution of the manufacturing sector is due to positive labour productivity growth rates in the sector. For economies with available data, we can draw finer conclusions for detailed manufacturing sub-sectors (See section 4.3).We estimate negative values for the allocation effect of manufacturing sectors in all countries, but the magnitudes differ. For ell countries except US, UK and France the positive 'within effect' of manufacturing compensates the negative allocation effect, and therefore the overall contribution made by manufacturing is positive. The overall contribution of manufacturing in US, UK is negative and in France close to zero. Figure 6 illustrates the above findings for the manufacturing sector as a whole.

China stands out with the largest labour productivity growth rates explaining by the 'within effect', which reflects the productivity gains of the manufacturing sector, which represents a sizeable part of the economy. The contribution 'within effect' in manufacturing to total growth was large in the rest of the Asian economies and was also positive but smaller for Germany and also positive in France. The picture for the US and UK manufacturing sectors is

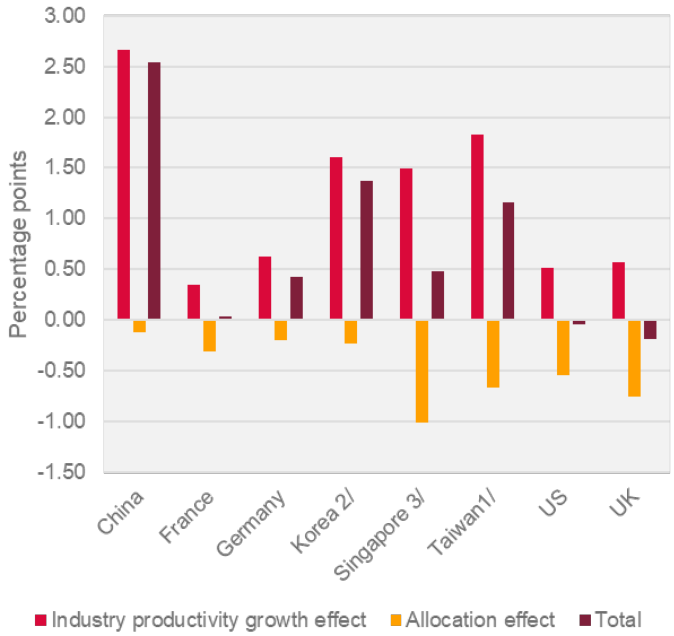
largely similar: *a negative allocation effect and a smaller positive within effect results in an overall negative contribution from manufacturing* to total labour productivity growth.

Table 4: Contributions to overall productivity growth by industry, 1998–2017.

Intra-industry productivity growth (within effect) (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 (between) 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.

Figure 6. Contribution of manufacturing to output per hour growth across countries, (1998–2017)



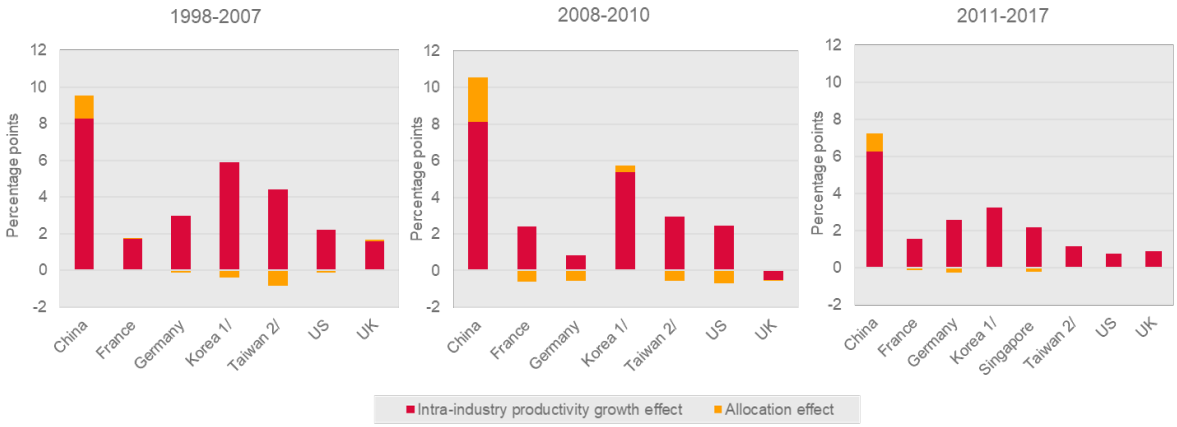
Note: Decomposition based on output per worker. [1/] Taiwan decomposition of productivity growth excludes agriculture, forestry and fishing, and public administration and defence, because of the unavailability of data. [2/]For Korea, the 2005–17 annual average is computed. [3/]For Singapore, the 2010–17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

Figure 7 below shows the evolution of the 'within effect' and 'between effect' across the economies examined. We distinguish three sub-periods: 1998-2007, 2008-2010 and 2011-2017. We see that the contribution of the 'within effect' continued to be positive at the heigh of the global financial crisis and subsequent recession in most Asian economies, and fell substantially in Germany, the UK and France.

Over the period 2011-2017 the contribution of the 'within effect' while positive everywhere, it has decreased. It is smallest in the US and the UK. The allocation effect is generally small and negative across all periods, except in the case of China. The allocation effect increased in the 2008-2010 but has fallen again to similar levels of the pre-crisis period.

Figure 7: *Decomposition of aggregate output per worker growth 1998–2017, selected economies*



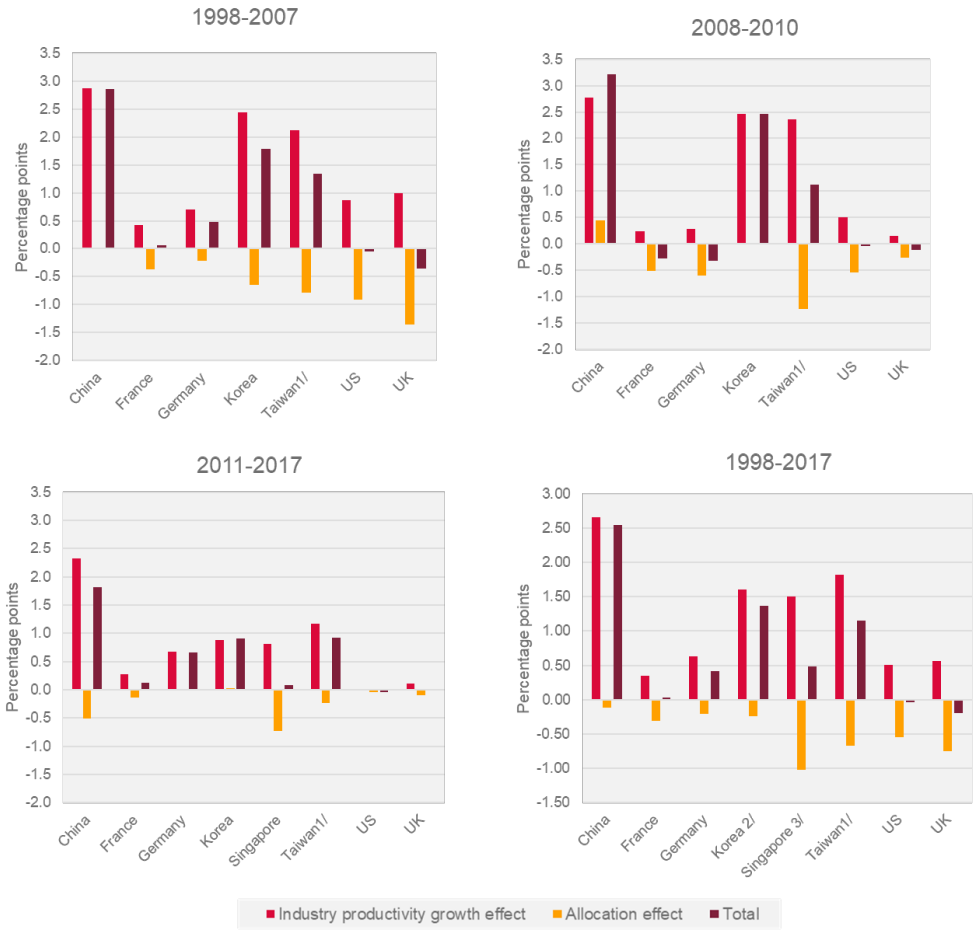
Note: Labour productivity measured as output per worker. [1/] For Korea, data on real estate, professional, scientific and technical activities, and administrative and support service activities, is excluded for the 1998–2004 period because of data unavailability. [2/] The decomposition for Taiwan excludes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

In section 2 we showed that, for the majority of countries, labour productivity in manufacturing has grown faster than the whole economy and other production and services sector. However, the growth of manufacturing productivity has also slowed down in the last decade. The impact of slower productivity growth in manufacturing concurs with the shrinking of output and employment shares, slowing down the contribution of this sector to aggregate productivity growth. Manufacturing as a whole tends to be more productive than the whole economy as a whole. We will explore these differences in more detail in section 4.2.

Figure 8 shows that the contribution of the manufacturing sector to total labour productivity growth has fallen. In some Western economies such as UK, US and France we see a continuation of a trend that started well before the financial crisis. Manufacturing has been making a small negative contribution to overall productivity growth, mainly because of the between effect, which was however a little larger in the decade before the financial crisis. For Germany, the case a is a little different as we see a sharp decline in the contribution made by manufacturing during the crisis years, but it has picked up again.

Figure 8: Contributions of manufacturing to aggregate productivity growth, 1998–2017



Note: Decomposition based on output per worker. [1/] Taiwan 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.

The shrinking of manufacturing has gone hand-in-hand with the expansion of service activities. Figure 9 illustrates the contribution made by different service sectors to total labour productivity improvements during the period 1998 to 2017; we see positive contributions from all services sectors. Across countries, sectors that have made a positive contribution to aggregate productivity growth include both: a) activities with productivity levels above the average (classified in this report as knowledge-intensive services), such as financial and insurance activities and professional, scientific and technical activities, but also: b)more labour-intensive activities with productivity levels that are below the average, such as wholesale and retail trade, human health and social work activities, and administrative and support services. For instance, in the wholesale and retail sectors the within-effect has been mostly positive and of larger magnitude than the negative allocation effect, which reflects a shrinking sector. In the case of administrative services, the allocation effect has mostly been positive and of larger magnitude than the within effect, reflecting in this case a growing sector. See figure 10.

The expansion of above-average productivity service activities has meant positive allocation effects across five of the eight economies examined (Figure 10). Taiwan, the UK and the US are the only exceptions, with negative, albeit small, allocation effects in knowledge-intensive services. These negative allocation effects arise largely developments in the information and communication sector, mainly because of reductions in its relative output prices. However, these negative allocation effects are compensated by the large within-industry component, which reflects rapid labour productivity growth in this sector.

Across all economies, knowledge-intensive services have generally made positive total contributions to national productivity growth (as we saw in table 4). These are mainly driven by professional, scientific and technical activities, the knowledge-intensive service sector that has seen one of the largest expansions, and also the financial and insurance activities sector, a sector with relatively high productivity levels and steady growth.

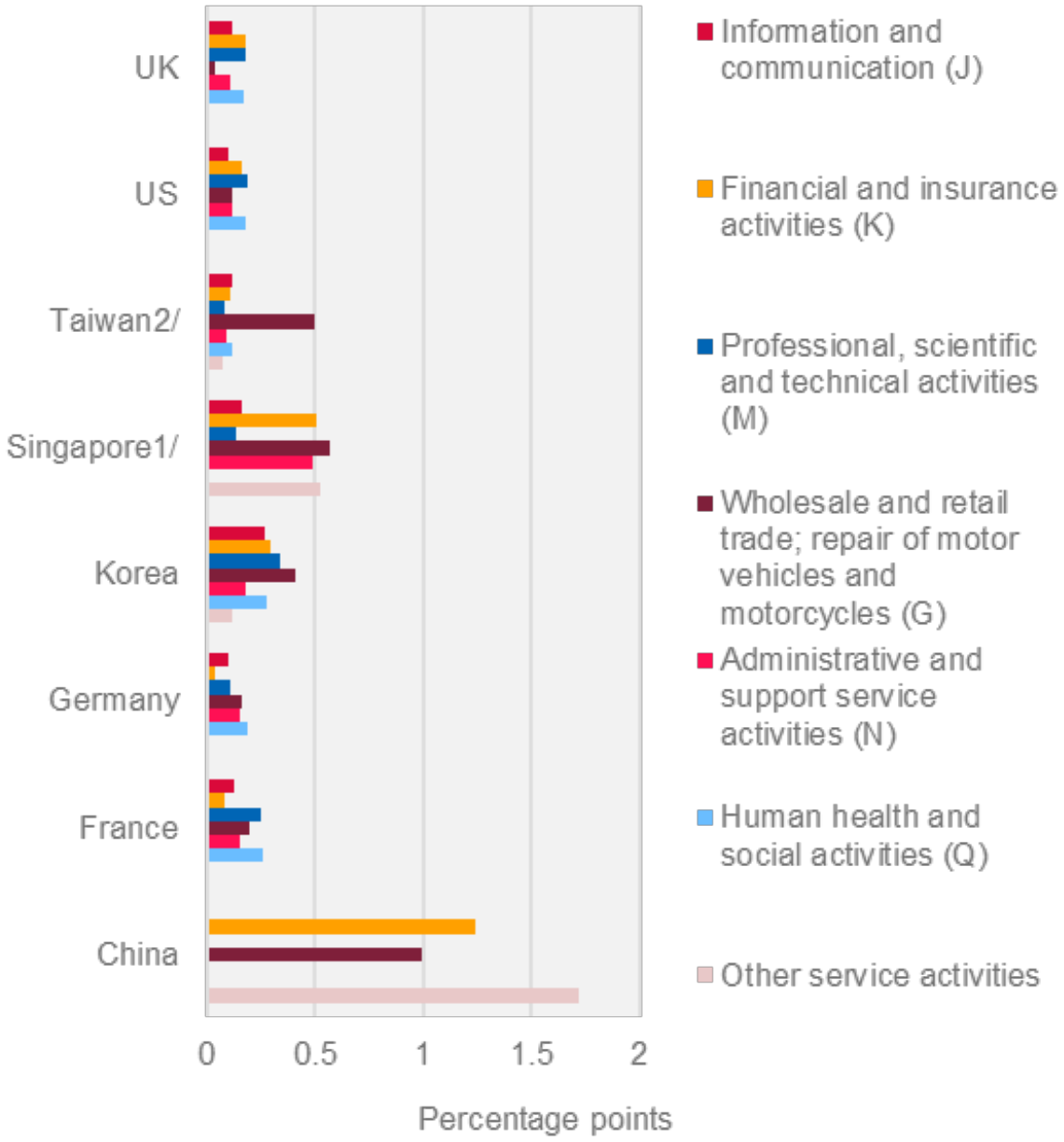
Service activities where a large proportion of the output involves non-market transactions have also made a substantial contribution to aggregate productivity growth across the economies examined. The contributions of these sectors were particularly large during the global financial crisis and in those countries most impacted by the crisis, such as France, Germany, the UK and the US. However, in the post-crisis period, public administration and defence has slowed down aggregate productivity growth in the US and the UK, which is largely explained by a reduction in the size of this sector.

In comparison, the contribution of human health and social work activities shows a steady increase. Considering the ageing of the population, it is expected that this sector will continue to expand thus increasing its contribution to aggregate productivity growth in the coming decades.[5] Cross-country comparisons of non-market services, however, should be interpreted with caution because the methods used to estimate the input and output of non-market services vary and the mix of public and private provision of service activities, such as healthcare, also differs across countries.[6]

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

[6] Coyle, D., Dreesbeimdieck, K. and Manley, A. (2021). Productivity in UK healthcare during and after the Covid-19 pandemic. The Productivity Institute working paper No.002.

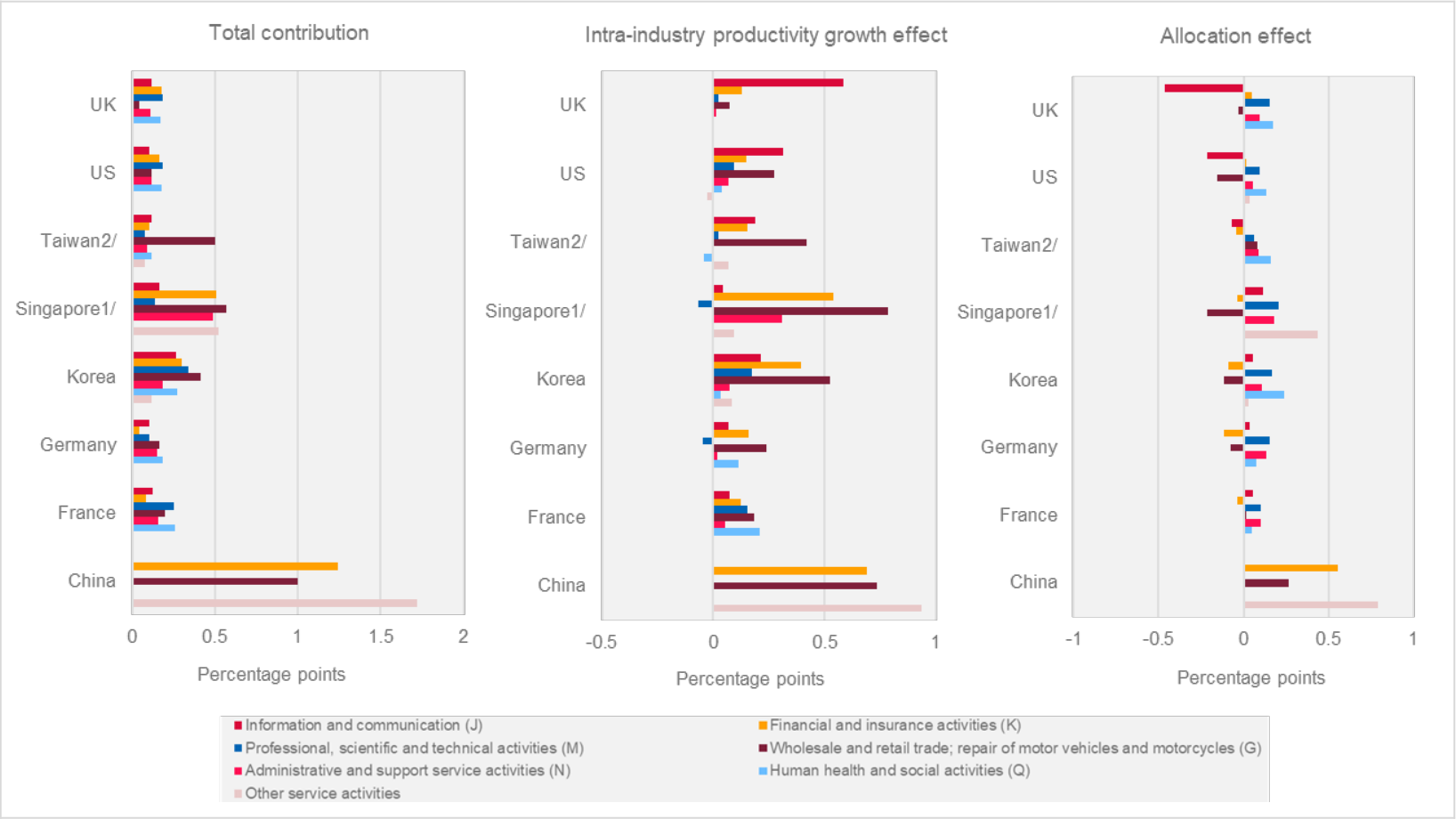
Figure 9. Contribution of selected service activities to aggregate productivity growth (1998–2017)



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 the unavailability of data. For China, the data for financial and insurance activities refers to financial intermediation, real estate, renting and business activities; and 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.); 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 10. 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.

4.2 Relative productivity levels.

Table 5 below shows industry productivity levels relative to those of the total economy. Note that these cannot be compared across countries and only within each country. These differences can help explain how the changing size of sectors determine the magnitude of the between effect for a particular industry in the Tang and Wang's methodology. These are estimated as an average for the period of analysis. The table demonstrate that the manufacturing tends to be more productive compared to the whole economy, but to varying degrees across countries. For the Western economies the manufacturing is between 15 per cent (in France) and 25 per cent (in the US) more productive relative to the total economy. The differences in productivity between manufacturing and the rest of activities are more marked in the case of the Asian economies. In Taiwan the manufacturing sector is around four times more productive.

Generally speaking, the agricultural sectors are less productive relative to the total economy (except in Taiwan and Singapore). The mining and utilities sectors tend to be more productive, and the construction sectors are characterised by lower labour productivity.

For services, the results are wide-ranging. The wholesale and retail, and transport and storage sectors have productivity levels slightly below (or in some cases *a la par*) of those of the total economy. The accommodation and food services activities sector have productivity levels well below the average, in all countries. Information and communication and financial activities are always more productive than the rest of the activities as a whole. This ranges between one a half and two times more productive. An exception is China, where the financial sector is relatively much more productive.

For business services, we see that the professional' scientific and technical sectors is slightly more productive, but this is not the case in Taiwan and the UK. In contrast the administrative and support services sector is uniformly less productive relative to the whole economy. This is similar to other services and art, entertainment and recreation activities.

For the non-market services (and bearing in mind the problematic measurement of output in these activities) we see that these tend to be less productive, at least in the Western economies.

Table 5. Sectoral productivity levels (Ratio relative to whole economy).

	China	South Korea	Taiwan	Singapore	United States	United Kingdom	Germany	France
Agriculture, forestry and fishing	0.3	0.39	1.64	1.39	0.57	0.42	0.43	0.39
Mining and quarrying	4.2	2.04	0.78	.	5.15	3.62	1.03	1.58
Manufacturing	1.8	1.53	4.63	1.40	1.26	1.16	1.19	1.15
Electricity, gas and water supply; sewerage, waste management and remediation activities	4.8	1.45	1.72	.	3.96	2.47	2.47	2.43
Construction	0.9	0.79	0.55	0.34	0.55	0.82	0.64	0.75
Wholesale and retail trade; repair of motor vehicles and motorcycles	1.1	0.56	0.87	1.30	1.03	0.77	0.73	0.79
Transportation and storage	2.1	0.66	0.89	1.17	0.58	0.68	0.87	0.88
Accommodation and food service activities		0.29	0.75	0.37	0.37	0.43	0.38	0.59
Information and communication		2.00	1.25	1.34	3.80	1.21	1.61	1.75
Financial and insurance activities	17.1	2.14	1.48	2.78	1.45	2.16	1.47	1.40
Real estate activities		3.56	7.37	1.97	7.50	8.18	10.90	8.76
Professional, scientific and technical activities		1.54	0.85	1.08	1.18	0.83	1.12	1.09
Administrative and support service activities		0.91	0.41	0.78	0.48	0.58	0.79	0.78
Public administration and defence; compulsory social security		1.63	7.30	0.61	0.79	1.06	0.93	0.94
Education		0.86	0.96		0.53	0.78	0.86	0.97
Human health and social work activities		0.85	1.30		0.60	0.61	0.58	0.68
Arts, entertainment, recreation		0.49	2.07		0.69	0.67	0.90	0.76
Other services	0.9				0.46	0.75	0.76	0.62
Activities of households						1.54	0.30	0.26
Whole economy	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

4.3 Detailed manufacturing sectors

Appendix tables A.1 to A.7 split the total contribution made by the manufacturing sector into the contribution of more detailed sub-sectors. We do not have these more granular data for some countries China and Singapore. Here we use output per hour as a measure of labour productivity, so the overall manufacturing contribution would not be strictly comparable to the ones we have shown in the main body of the report.

Generally, these tables show us the manufacturing sub-sectors making the largest contributions to aggregate labour productivity growth during our period of analysis include: transport equipment; computer, electronic and optical products; chemical products (including pharmaceuticals); and machinery and equipment. There are however differences across countries. The contribution of these industries to aggregate productivity growth is larger (more than 15%) in Germany, Korea and Taiwan, where manufacturing output accounts for over one fifth of the total economy.

The contributions made by traditional manufacturing sectors, such as manufacturing of food and beverages, textiles and furniture has been mostly negative.

4.4. Excluding sectors with problematic measurement

Improving the measurement of public-sector productivity is a long-standing and complex challenge for national statistical offices, as the measurement of service output is more complicated than the measurement of the production of goods in the market sector. In the public sector context, it can be difficult to identify the output of services, as well as the inputs required to produce them, and any changes in efficiency and effectiveness 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 in measuring output of public services. Traditionally, public sector outputs have been measured indirectly, by means of the output equals input convention. This approach however is not considered satisfactory as 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.

Cross-country measures of productivity have to be interpreted carefully and need to be monitored to ensure that they capture changes in quality. Its measurement affects analyses of the relative growth rates across different countries as these apply a variety of methods to estimate output and inputs of the public sector. Reliable comparisons would require of good quality and, if possible, internationally comparable input and output measures of public sector services.

Work to develop methods for measuring public service areas is ongoing in countries like the UK, following the principles of the Atkinson Review (Atkinson, 2005). Different sectors are subject to direct measures of output, for instance Health, Education and some parts of Public Administration. 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. Output numbers that are not quality-adjusted or standardized may indicate misleading productivity signals.

We compute the sectoral contributions to overall labour productivity growth taking into account the market sector only (and thus we exclude education, health and public administration sectors). In addition, we exclude from the computation a market sector with notorious measurement problems: the real estate sector. It is not unusual to exclude this sector from analyses (Riley et al, 2018), 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 boosts measured labour productivity above that observed in other sectors, and can distort the sector's contribution to aggregate productivity.

Tables A.8 and A.14 in the Appendix III contains the results of our labour productivity growth decomposition after excluding these sectors. In the case of China and Singapore we do not have information on the public industries. Appendix IV is a summary of the results.

Generally, we find that the overall labour productivity growth rate is higher when we exclude the mostly public sectors and real estate (except in the case of UK and France). In the UK the allocation effects are more negative and in the case of France it is the within effect that becomes smaller. In the rest of the countries the greater labour productivity growth is explained mostly by an increase in the within-effect.

When we exclude these sectors, the relative contribution of manufacturing increases in those countries for which the contribution made by the manufacturing sector to overall productivity growth was positive. This is the case of China, Taiwan, South Korea and Germany. For US the contribution of manufacturing becomes slightly positive and for the UK es slightly more negative.

5. Country-specific highlights.

5.1. China

- China has achieved great economic success in the last few decades but and labour productivity improvements have been facilitated by the development of the industrial sector and the absorption of technology from abroad. China's productivity growth however has declined steadily since the global financial crisis. China has seen a steady shift of labour from the agricultural sector, where labour productivity is lower (See table 5), to manufacturing and services, where labour productivity is higher, and this has increased overall labour productivity. However, this productivity-boosting effect of the movement of labour appears to be slowing down.
- Similar to other economies, China's productivity growth has declined markedly in the last decade, from an annual average rate of 9.5% in 1998–2007 to 7.3% in 2011–2017. Reasons include the fact that the speed the reallocation of labour from agriculture to other industries has slowed down; and labour has started has also to shift from manufacturing to services with relatively lower labour productivity. Many services in China are not internationally tradable, and therefore not exposed to international competition.
- Overall, the sectors with the largest contributions to China's aggregate productivity during the period of 1998–2018 include: manufacturing; community, social and personal services; financial and insurance activities; and wholesale and retail trade.
- The large contribution of manufacturing to aggregate productivity growth is explained by a high rate of productivity growth (8.3% annual average, 1998–2018). However, this sector

experienced reductions in output shares and relative output prices between 1998 and 2018, which it means a declining contribution to aggregate productivity growth.

- During the post-crisis period (2011–18), the contribution of manufacturing to aggregate productivity declined, while the service sectors increased their contributions. This includes both high-productivity services, such as financial activities, and services with relatively lower productivity, such as community, social and personal services, which saw the largest increase.
- The productivity of the agricultural sector has improved rapidly achieving rate of at 6.8% between 1998 and 2018, which led to positive contributions to aggregate productivity.
- Overall service activities have made a substantial contribution to China's aggregate productivity growth, of 4.6 percentage points between 1998 and 2018 on average. This is the sum of the contributions of: community, social and personal services (1.7 percentage points); financial and insurance activities (1.2 percentage points); wholesale and retail trade (1.0 percentage points); and transportation and storage (0.7 percentage points).

5.2 South Korea

- The sectors that made the largest contributions to Korea's labour aggregate productivity in 1998–2018 include: manufacturing (30.6%); wholesale and retail trade (8.1%); real estate activities (7.4%); public administration and defence (7.0%); and professional, scientific and technical activities (6.5%).
- The sizeable contribution of Korea's manufacturing sector to aggregate labour productivity growth is explained the fast productivity growth of the sector, and the relatively large size of (29.1% output shares and 16.8% employment shares in 2018). This results in a large 'within effect'.
- Korea's manufacturing had one of the highest productivity growth rates across sectors (8.6% in 1998–2018), but it experienced a major slowdown from an annual growth rate of 11.4% in 1998–2007 to 5.6% in 2011–18.
- The contribution of Korea's manufacturing sector to aggregate productivity growth declined during the period of analysis was due partly by a contraction in the size of the sector. Manufacturing employment shares went from 19.5% in 1998 to 16.8% in 2018. This was amplified by reductions in relative output prices of -6.6 percentage points between 1998 and 2018. We estimate that the shrinking of manufacturing is responsible for a reduction in -0.5 percentage points of Korea's aggregate productivity growth by on average, between 1998 and 2018 (allocation effect).
- The manufacturing sub-sectors contributing the most to aggregate productivity gains in 1998–2018 include (in brackets relative contributions): the manufacture of computer, electronic and optical products (10.2%); chemical, rubber, plastics, fuel products and other non-metallic mineral products (5.6%); the manufacture of basic metals and fabricated metal products (4.3%); the manufacture of transport equipment (3.0%); and the manufacture of machinery and equipment (2.5%).
- Within manufacturing, the manufacture of computer, electronic and optical products is the sub-sector that made the largest contribution to aggregate productivity growth, with 10.2% of total in 1998–2018. This industry represents around a third of Korea's manufacturing value added.
- The manufacture of computer, electronic and optical products represents around a third of Korea's manufacturing value added. The industry dates back to the mid-1960s, when the

government developed a strategy to diversify its manufacturing base. The government supported Korean firms to develop production and innovation capabilities while facilitating partnerships with foreign companies.[7] Public research and development organisations, including the Electronics and Telecommunications Research Institute (ETRI), established in 1976, and the Korea Electronics Technology Institute (KETI), established in 1991, have also played a key role in the development of the electronics industry in Korea.[8]

- In the 1980s and early 1990s, the government shifted its focus from consumer electronics to information and communications technology (ICT), and Korean firms diversified their products and developed core components and materials by expanding their investments in research and development.[9]
- Korea's main strengths in the electronics value chain are in integrated circuits (memory), led by Samsung and Hynix, displays (Samsung Display and LG Display) and mobile phones (Samsung, LG).[10] In 2015 Korea ranked fourth in the global ranking of the electronics industry in terms of output, behind China, the US and Japan.[11]
- The contribution of wholesale and retail trade to aggregate productivity growth is explained by its high productivity growth (6.9% in 1998–2018). Factors that help to explain the high productivity of the wholesale and retail trade sector include: the entrance of new actors; the emergence of new (mainly online) retail channels, and sustained investments in digital technologies.[12]
- While the manufacturing has sector shrunk, service activities saw large expansions between 1998 and 2018, including (in brackets, changes in employment shares): human health and social work activities (5.8 percentage points.); arts, entertainment, recreation and other services (1.7 percentage points); education (1.0 percentage points); information and communication (0.6 percentage points); and transportation and storage (0.5 percentage points) (Table 6).
- The contribution of professional, scientific and technical activities to aggregate productivity growth is explained by the expansion of this sector, which shows productivity levels above the average and relatively large productivity growth rates (4.8% in 1998–2018) (Table 6). Korea's spending on R&D as a proportion of its GDP is the second largest globally (4.6% in 2019), behind only Israel.[13] The government has been expanding funding for basic research in recent decades, with the aim of becoming a global leader in this area.[14]
- The rising contribution of construction is the result of an expansion of this sector in the post-crisis period, a 1 percentage point increase in output shares and a 0.3 percentage point increase in employment shares in 2011–18, in combination with high productivity growth rates (5.8%, on average, in 2011–18) (Table 5). The Korean government supported the recovery of the construction industry after the global financial crisis, investing in four major

[7] Lim, W. (2016). The Development of Korea's Electronics Industry During Its Formative Years (1966-1979). Ministry of Strategy and Finance.

[8] Frederick, S. and Lee, J. (2017). Korea and the Electronics Global Value Chain. Korea Institute for Industrial Economics and Trade. Duke Global Value Chains Center.

[9] Lim, W. (2016). Op. cit.

[10] Frederick, S. and Lee, J. (2017). Op. cit.

[11] Lim, W. (2016). Op. cit.

[12] Cho, J., Chun, H. and Lee, Y. (2022). Productivity dynamics in the retail trade sector: the roles of large modern retailers and small entrants. *Small Bus. Econ*. https://doi.org/10.1007/s11187-022-00632-7; Retail Insight Network (2021). South Korea plans to inject $267m to support retail digitalisation; USCS Korea (2021). Korea: retail industry.

[13] Policy Links (2022). UK Innovation Report 2022. Benchmarking the UK's Industrial and Innovation Performance in a Global Context. IfM Engage. Institute for Manufacturing, University of Cambridge.

[14] Kim, S.Y. (2022). To boost basic science, look to values, not just budgets. *Nature*, Vol. 6.

river projects and creating a housing renting scheme that boosted private investment in housing. The productivity increase of the construction sector has also been supported by the development of technical and professional education programmes in subjects relevant to the industry and the establishment of a national roadmap for the adoption of smart technologies.[15]

5.3 Taiwan

- The slower labour productivity growth experienced in Taiwan in the post-crisis period reflects a broad-based slowdown in productivity growth across sectors. While developments within sector (within effect) may have played the greatest role, changes in the structure of the economy have also been a contributing factor.
- Manufacturing has seen a reduction in size (decrease by 6.05 percentage points in employment shares and decrease by-35 percentage points in relative output prices), and this explains the overall negative contribution to aggregate productivity growth, of -0.7 percentage points per year, on average, between 1998 and 2019.
- In the case of the manufacture of electronic parts and components and of computers, electronic and optical products, the large negative effects are explained by reductions in relative output prices. These manufacturing activities contributed the most to aggregate productivity growth because of their high productivity growth. Together, these industries accounted for 28% of the aggregate productivity growth seen in 1998–2019.
- 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 participation is even 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%.[16]
- Taiwan is home to the world's largest semiconductor foundry, the Taiwan Semiconductor Manufacturing Company (TSMC), and the largest integrated circuit packaging and testing firm, Advanced Semiconductor Engineering, Inc. (ASE). The semiconductors industry has been a priority in national development plans since the 1970s, when the Industrial Technology Research Institute of Taiwan (ITRI) was established. Since then, ITRI has led the development of the semiconductor industry and the creation of successful spin-off companies, such as TSMC. In the 1980s and the decades that followed, further government support was provided to this sector, including grants, subsidies, tax incentives and additional investments in research and industry infrastructure.[17]
- The shrinking of mining and quarrying, wholesale and retail trade, and information and communication (which have seen reductions in relative output prices) have resulted in declining contributions to total productivity growth in Taiwan.
- Although the wholesale and retail trade sector has seen slower productivity growth its large size explains the sector's relatively large contributions to aggregate productivity growth, the within effect is larger than the allocation effect.

[15] Lee, C. (2021). Construction Industry Progress of South Korea: 1995–2019. In: Anson, M., Chiang, Y.H., Lam, P. and Shen, J. (Eds). Construction Industry Advance and Change: Progress in Eight Asian Economies Since 1995, Emerald Publishing Limited, Bingley, pp. 137–161. https://doi.org/10.1108/978-1-80043-504-920211007

[16] 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

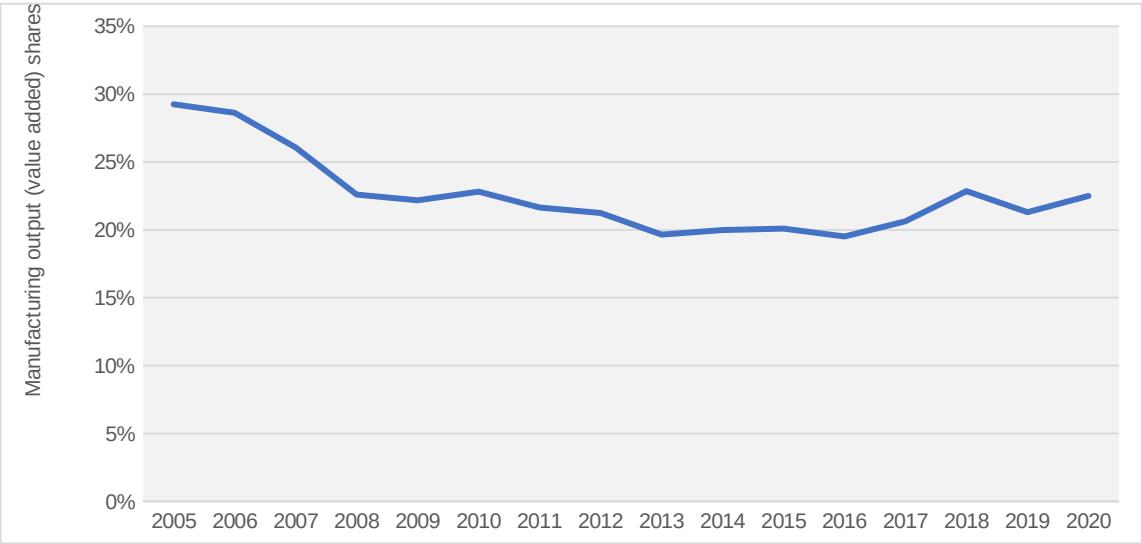
[17] Ibid.

- In comparison, expansions of service activities with relatively higher productivity levels (e.g. professional, scientific and technical activities) or increases in relative output prices (e.g. human health and social work activities) have resulted in positive contributions to aggregate productivity growth.

5.4 Singapore

- Manufacturing plays a key role in Singapore's economy, and it constitutes a priority in national industrial and innovation policy. Although the share of manufacturing in total employment has been decreasing (falling by 10 percentage points between 2005 and 2015), this trend seems to have stalled in recent years, and the share of manufacturing in total output continues to be above 20%. We see that manufacturing continues to make a relatively large contribution to Singapore's aggregate productivity growth.

Figure 11: Singapore: Manufacturing output shares 2005–2020



Source: Authors' computation, based on data from the Singapore Department of Statistics.

- Electronics and precision engineering are two of the main industries driving productivity growth in manufacturing.[18] It is estimated that for every Singaporean dollar of value added generated by the manufacturing sector, a corresponding 0.28 Singaporean dollars are produced in the rest of the economy, particularly in knowledge-intensive services.[19]There is a close link between the manufacturing and knowledge-intensive activities in Singapore, and for instance the development of Singapore's biomedical industry illustrates these synergies. In 2000 the Singaporean government launched a strategy to develop a biomedical industry. The early stages required the development and attraction of scientific talent and proactive attraction of foreign direct investment, while the more recent phases saw many companies locating manufacturing, research and management activities in the country.[20]
- The manufacturing sector features prominently in Singapore's innovation and industrial policy. Public investments in research and development prioritise advanced manufacturing and engineering technologies. The Research, Innovation and Enterprise 2025 (RIE 2025) Plan has allocated S$25 billion for basic and applied research on manufacturing and aims to

[18] The World Bank (2019). Singapore. Overview.

[19] National Research Foundation (2021). Manufacturing, trade and connectivity. RIE2025 Plan.

[20] Policy Links (2021). Singapore's Biomedical Cluster. Lessons from two decades of innovation and manufacturing policy.

strengthen Singapore's manufacturing competitiveness, investing in deepening capabilities in areas such as supply chain management, microelectromechanical systems and artificial intelligence.[21] In addition, the 10-year 'Manufacturing 2030' plan, announced in 2021, set the goal to grow manufacturing value added by 50%, while maintaining a share of approximately 20% of the gross domestic product.[22]

- Sectors that have increased their contribution to Singapore's economy between 2010 and 2019 include: financial and insurance activities (↑3.2 percentage points output shares and ↑0.51 percentage points employment shares); administrative and support service activities (↑1.82 percentage points output shares and ↑1.29 percentage points employment shares); information and communication (↑0.98 percentage points output shares and ↑0.79 percentage points employment shares); other service activities (↑0.79 percentage points output shares and ↑1.69 percentage points employment shares); and professional, scientific and technical activities (↑0.10 percentage points output shares and ↑0.78 percentage points employment shares) (Table 2).
- These sectors include both high-productivity activities (financial and insurance, information and communication, and professional, scientific and technical activities) which have seen an expansion, and low-productivity activities (administrative and support services and other service activities).
- 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 whole value chain: multilateral banks, private financiers, lawyers, accountants, engineers and other professional services.[23]

5.5. United States.

- The sectors that made the largest contribution the US' aggregate productivity growth during the period 1998–2019 are in the services sector and include: professional, scientific and technical activities; financial and insurance activities. real estate and rental and leasing; public administration and defence; human health and social work activities.
- Important differences are found in sectoral contributions when we compare the pre- and post-financial crisis periods. During the global financial crisis, and in its aftermath, public administration and defence accounted for one-third of the aggregate productivity growth observed in 2008–10, more than twice the contribution seen in the pre-crisis period.
- In the post-crisis period (2011–19), the productivity growth slowdown is evidence across most sectors of the economy. The market sectors that saw the largest declines in their contributions include: mining and quarrying; professional, scientific and technical activities; construction; information and communication; and wholesale trade. In relative terms, financial and insurance activities and real estate and rental and leasing saw the largest increases in their contributions in the post-crisis period.
- The large contribution from the professional, scientific and technical activities and financial and insurance activities is explained by their positive productivity growth performance. The professional, scientific and technical activities is a sector in continuous expansion.

[21] Ibid.

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

[23] The World Bank (2019). Singapore. Overview.

- The US manufacturing sector has experienced a decline in size, and overall this sector makes a negative impact on the aggregate productivity growth, particularly between 1998 and 2010.
- Other sectors that saw relatively large declines in their employment shares, and for which we compute negative allocation effects, include: retail trade, wholesale trade, and information and communication.
- Our results suggest productivity problems in construction and utilities industries, where productivity growth is low or negative. There are evidence suggesting that there are underlying problems associated with regulation and lack of effective competition in these sectors.

5.6 United Kingdom

- The sectors that contributed the most to the UK's aggregate productivity growth during the period of 1998–2019 include: professional, scientific and technical activities (15%); human health and social activities (15%); financial and insurance activities (14%); construction (12%); and information and communication (10%).
- Important differences are found in the sectors' contributions between the pre- and post-financial crisis periods. The market sectors that to a larger extent, help to explain the slowdown in the UK's productivity growth in the last decade include: financial and insurance activities; professional, scientific and technical activities; information and communication; wholesale and retail trade; and mining and quarrying.
- The deceleration in productivity growth has been especially pronounced the UK compared to other countries and generally this observed across most sectors of the economy. While the UK productivity growth decline since the financial crisis is mainly explained by slower growth across all sectors (Riley et al, 2018). However, changes in the structure of the economy have also slowed down aggregate productivity growth, but this is smaller.
- The shrinking of the manufacturing sector, a trend largely observed between 1998 and 2007, has been a major development affecting the UK's economy structure and productivity in the last few decades. On average, we estimate that the shrinking of manufacturing, involving reductions in employment shares and relative output prices, accounted for an annual decline in productivity growth of around -0.7 percentage points during the 1998–2019 period.
- Reductions in relative output prices of information and communication also slowed aggregate productivity growth by -0.45 percentage points in 1998–2019[24]. In addition, contractions of mining and quarrying, mainly caused by reductions in the relative output prices of this sector, and public administration and defence, explained by declines in employment shares, have slowed down aggregate productivity growth, particularly in the post-crisis period. Each of these sectors made negative annual contributions of -0.07 percentage points, on average, between 2011 and 2019.

[24] Statistical challenges may play a role in explaining the decline in labour productivity growth observed in many countries. This is relevant in particular to the measurement of price adjusted gross value added (Ademmer et al., 2017). This is more important for products that are subject to rapid technological change and sectors such as the ICT sector. If quality enhancements are mistaken as pure price increases, this will likely result in underestimation of gross value added, and therefore of the labour productivity growth. There is much debate that deflation problems could play a role in explaining the lack of productivity gains. The potential held by digitalisation has yet to be realised in the economy and therefore the value of many digital goods and service is not fully captured yet by national statistics. In recent years the UK Office for National Statistics has revised the deflators for the information and communications sectors, and this has resulted in a slight revision upwards of the output and productivity figures.

- In comparison, the construction sector and selected service activities have increased their contribution to overall productivity growth, as they expand and experience accelerating productivity growth. Services that have contributed to improving aggregate productivity include: human health and social activities; professional, scientific and technical activities; administrative and support service activities; and information and communication services.

5.7 Germany

- The sectors that made the largest contributions to Germany's labour aggregate productivity in 1998–2017 include: manufacturing (23.9%); real estate activities (9.8%); wholesale and retail trade (9.7%); administrative and support service activities (8.0%); and human health activities (6.5%).
- During the crisis and in its aftermath (2008–10) mostly non-market services drove productivity growth. In the decade that followed (2011–17) manufacturing, wholesale and retail trade, and professional, scientific and technical activities, saw an increase in their relative and absolute contributions to aggregate productivity growth.
- The contribution of manufacturing to aggregate productivity growth is explained by its large size (22.8% output and 17.2% employment shares in 2017) and its high productivity growth (3.0%, on average, in 1998–2017).
- Manufacturing sub-sectors that experienced the fastest productivity growth in 1998–2017 include (in brackets, annual average growth): the manufacture of transport equipment (5.3%); the manufacture of machinery and equipment (3.1%); the manufacture of computer, electronic and optical products (3.1%); and the manufacture of textiles, wearing apparel, leather and related products (3.1%) (Table 2)
- A variety of factors help to explain the remarkable performance of Germany's manufacturing sector. These include: a skilled workforce, a strong innovation ecosystem and a competitive export position. Germany's dual system of vocational education and training, which combines practical with classroom-based learning, is a key source of high-skilled manufacturing workers. Germany is characterised by strong worker training, despite does not have the innovative IT sector as the US (See Baily et al).
- Although manufacturing continues to be a key driver of Germany's productivity growth, it experienced a contraction in the last two decades, particularly between 1998 and 2010. This contraction has slowed down aggregate productivity growth, by -0.14 percentage points, on average, in 1998–2017. Yet the contribution of manufacturing to aggregate labour productivity growth is considerable.
- Within manufacturing, transport equipment is the manufacturing sub-sector that made the largest contribution to aggregate productivity growth, with 9% of total in 1998–2017. Automotive is the largest industry in Germany, accounting for around 20% of the total German industry revenue in 2021.[25] Germany's automotive sector is the country's most innovative industry, accounting for 35% of total German business R&D expenditure of around EUR72 billion in 2018. Germany has the highest concentration of all European automotive original equipment manufacturers (OEM) and tier supplier R&D centres. Small and medium-

[25] Germany Trade and Invest (2022). Automotive Industry.

sized companies play a key role in Germany's automotive industry, and around 85% of the industry suppliers are medium-sized companies.[26]

- As the manufacturing sector contracted, services increased their significance in the economy. Service activities that saw among the largest improvements in their contributions to aggregate productivity growth between the pre-crisis and post-crisis periods include: human health activities (0.08 percentage points); wholesale and retail trade (0.07 percentage points); residential care and social work activities (0.05 percentage points); and professional, scientific and technical activities (0.05 percentage points).
- Overall, the proportion of the German workforce working in the service sector has increased facilitated by labour market reforms, which also changed the significance of the different forms of employment.

5.8 France

- The sectors that contributed the most to France's labour aggregate productivity performance during the period in 1998–2017 include (in percentages of total growth): real estate activities (15.8%); professional, scientific and technical activities (10.9%); wholesale and retail trade (9.3%); construction (7.1%); and administrative and support service activities (7.0%).

- In the pre-crisis period (1998–2007), the top five sectors driving productivity growth were: real estate activities (17.5%); professional, scientific and technical activities (10.7%); wholesale and retail trade (9.5%); construction (9.0%); and administrative and support service activities (7.8%).

- Manufacturing is the sector with the second-largest intra-industry productivity growth effect (productivity growth weighted by output share) in 1998–2017, behind real estate activities; however, it has experienced a significant contraction, slowing down the contribution to aggregate productivity growth. Manufacturing employment shares fell by 4.8 percentage points between 1998 and 2017.

- The manufacture of chemical, rubber, plastics, fuel products and other non-metallic mineral products and the manufacture of transport equipment are among the industries that have experienced the largest contractions. These industries were severely impacted during the global financial crisis, and they have struggled to remain competitive, a phenomenon observed since the late 1990s.

- During the Great Recession (2008–10) the (mostly) non-market services experienced positive productivity growth. In the decade that followed (2011–17), manufacturing saw an increase in its relative and absolute contributions to aggregate productivity growth, in comparison with those observed in the pre-crisis period. Most sectors experienced slower productivity growth and thus reductions in their contributions to aggregate productivity growth.

- The performance of wholesale and retail trade sector continue to spur total labour productivity growth mainly due to healthy productivity growth in a sector accounting for around 13% of total output and employment; the positive contribution from the administrative and support services sector stems from the on-going expansion of the sector.

[26] Germany Trade and Invest (2020). The Automotive Industry in Germany. *Industry overview*. Issue 2020/2021.

- Professional, scientific and technical activities, with higher than average productivity, have experienced an expansion in size and contribution has risen steadily.

6. Concluding remarks

Since the financial crisis we have witnessed contemporaneous productivity decelerations among developed and emerging economies. But far from revealing a compelling story, we find that the weakening of productivity growth responds to a mix of common and idiosyncratic factors in each of the countries. By looking at detailed industry-level data for eight major world economies this report contributes to a finer understanding of aggregate labour productivity growth trends in the last two decades.

We observe a structural shift from the manufacturing sector towards services in most of the economies examined here, except in China and to a lesser extent in Germany. We find that although deindustrialisation has been a dominant trend among the majority of economies analysed, the manufacturing continues to be a key driver of national productivity growth in the economies where manufacturing accounts for more than 20 per cent of value added, such as China, Korea and Taiwan as well as Germany. The structural shift in economic activity towards the service sector and away from manufacturing reflects the increasingly global division of labour and is often identified as the main reason for the slowdown in productivity performance in advanced economies, as manufacturing is more productive than the services sector as a whole.

In the US and UK developments in the manufacturing sector represent a drag from overall growth (up to -0.2 per year in the UK); in the case of France this is more negligible. These are the result mainly of negative reallocation that reflects reallocation of resources away from a higher-than average productivity sector.

In China, the contribution of manufacturing to aggregate productivity has declined, while the service sectors increased their contributions. This is the case for both high-productivity services, such as financial activities, and services with relatively lower productivity, such as community, social and personal services, which saw the largest increase.

Our research also reveals productivity problems of sectors like utilities and construction sectors in countries like the UK and US.

In the years to come, as the economies continue shifts more from industry to services, overall productivity growth could slow further, as the industrial sector tends to be more productive However, among services we find productivity in the service sector is not uniform, and the tertiarization of the economy should not prevent the universal realisation of productivity gains. The increased importance of services can explain some of the slowdown in productivity growth in the total economy, but these continue to make positive contributions to total growth (although these have been declining), and there is potential to boost productivity across all sectors of the economy.

7. References

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

Aubrey, T. (2021). Will boosting aggregate demand increase UK productivity growth?; The Productivity Institute.

Asian Productivity Organization, APO (2022). APO Productivity Outlook 2022. Manufacturing labour productivity: Trends and linkages. Tokyo: Asian Productivity Organization.

Baily, M.., Bosworth, B.P., and S. Dosh (2020), Lessons from productivity comparisons of Germany, Japan, and the United States", International Productivity Monitor, Spring 2020, pp. 81-103.

Dieppe, A. (ed.) (2021). Global Productivity: Trends, Drivers, and Policies. Washington, DC: World Bank.

Diewert, W.E. (2015), Decompositions of productivity growth into sectoral effects. *Journal of Productivity Analysis*, 43, 367–387.

Duernecker, G, Herrendorf, B and Valentinyi, A. (2017). Structural Change within the Service Sector and the Future of Baumol's Disease. London, Centre for Economic Policy Research.

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.

Gordon, Robert J. 2015. Secular Stagnation: A Supply-Side View. *American Economic Review*, 105 (5): 54-59.

Infocom Media Development Authority – Monitor Deloitte (2018). The future of services. Services and Digital Economy Technology Roadmap.

Marin, D. (2018). Explaining Germany's Exceptional Recovery. London: Centre for Economic Policy Research.

National Institute Economic Outlook, Spring 2022.

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

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

Timmer, M. P., Inklaar, R., O'Mahony, M. and B. van Ark (2010), Economic growth in Europe: a comparative industry perspective, Cambridge University Press.

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
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.

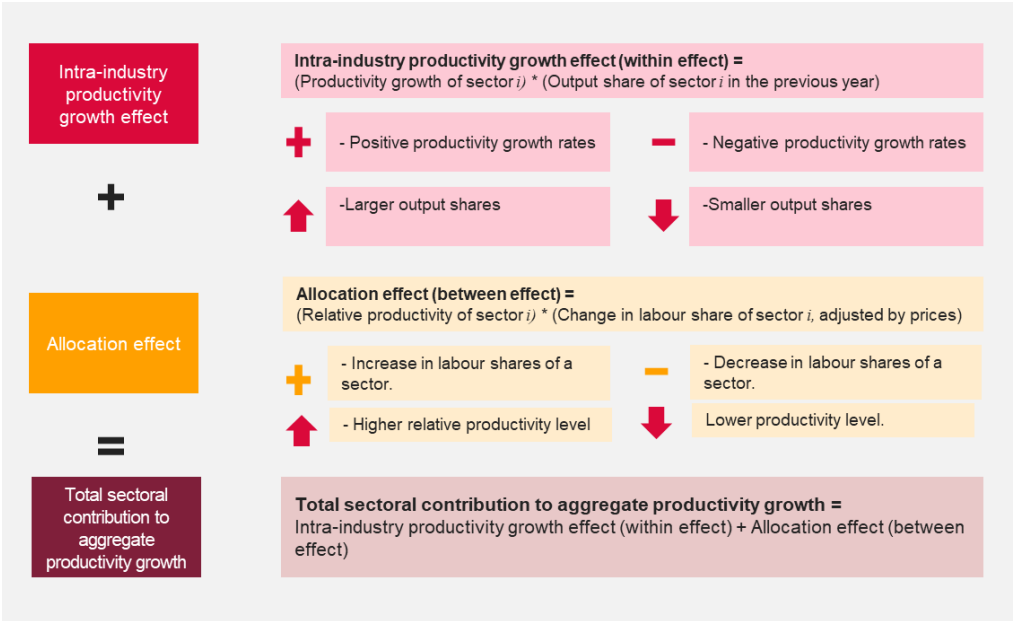
Economy	Variable	Measure, units	Source
United Kingdom	Labour (people)	Total jobs (thousands)	UK Office for National Statistics, Compendium of data related to labour productivity by low-level industry. January 2022 release.
United Kingdom	Output (real values)	GVA in pounds millions chained volume measure (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 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. Illustrating the decomposition of labour productivity growth

Measures of economy wide productivity growth cannot be obtained as a simple weighted sum of the corresponding industry measures, and changes in the allocation of resources across industries can make an important contribution to aggregate productivity gains. We apply the Generally Exactly Additive Decomposition (GEAD) by Tand and Wang (2004) to examine the sources of industrial contribution to aggregate labour productivity growth across countries. The methodology by Tang and Wang (2004) has the advantage that it allows us to estimate exactly additive sectoral contributions to aggregate labour productivity growth, even when output is measured in chain linked volumes. This methodology recognises that economy-wide labour productivity growth rates depend on: a) sectoral productivity growth rates, b) real output price changes, as well as c) changes in sectoral labour input shares

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 output prices in sector i change in relation to changes in the output prices of the whole economy.

Figure A.1: Decomposition of labour productivity growth, based on Tang and Wang (2004)



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

Appendix III: Tables

Appendix table A.1. *Contributions to overall productivity growth by manufacturing sub-sectors in Taiwan, 1998–2019*

Manufacturing sub-sector	1998–2007 (average, percentage points)			2008–2010 (average, percentage points)			2011–2019 (average, percentage points)			1998–2019 (average, percentage points)		
	Intra-industry productivity growth effect	Allocation effect	Total	Intra-industry productivity growth effect	Allocation effect	Total	Intra-industry productivity growth effect	Allocation effect	Total	Intra-industry productivity growth effect	Allocation effect	Total
Manufacture of food products	0.03	-0.05	-0.02	0.00	0.05	0.06	0.00	0.04	0.04	0.01	0.00	0.02
Manufacture of textiles	0.04	-0.08	-0.04	0.02	-0.02	0.00	0.00	0.01	0.01	0.02	-0.03	-0.02
Manufacture of wearing apparel	-0.01	0.00	-0.01	0.00	0.00	0.01	0.01	-0.01	0.00	0.00	0.00	0.00
Manufacture of leather and related products	0.00	-0.01	-0.01	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00
Manufacture of wood and of products of wood and cork	0.01	-0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Manufacture of paper and paper products	0.03	-0.03	0.00	-0.01	0.03	0.02	0.01	0.00	0.00	0.02	-0.01	0.01
Printing and reproduction of recorded media	0.03	-0.01	0.01	0.00	0.01	0.00	0.00	0.00	0.00	0.01	-0.01	0.01
Manufacture of coke and refined petroleum products	0.16	-0.08	0.09	-0.05	-0.13	-0.18	-0.04	0.04	-0.01	0.05	-0.04	0.01
Manufacture of chemicals	0.19	-0.11	0.08	0.07	0.21	0.28	0.04	-0.03	0.01	0.11	-0.04	0.08
Manufacture of other chemical products	0.02	-0.01	0.01	0.03	0.01	0.04	0.02	0.00	0.02	0.02	0.00	0.02
Manufacture of basic pharmaceutical products and pharmaceutical preparations	0.01	0.00	0.02	0.00	0.02	0.02	0.00	0.01	0.01	0.00	0.01	0.01
Manufacture of rubber products	0.01	0.00	0.01	0.01	-0.01	0.01	-0.01	0.02	0.01	0.00	0.01	0.01
Manufacture of plastic products	0.02	-0.07	-0.05	0.01	0.05	0.06	0.03	0.01	0.04	0.02	-0.02	0.00
Manufacture of other non-metallic mineral products	0.07	-0.04	0.03	0.14	-0.12	0.03	0.02	-0.05	-0.03	0.06	-0.05	0.01
Manufacture of basic metals	0.07	0.04	0.11	0.07	-0.04	0.04	0.11	-0.11	0.00	0.09	-0.03	0.06
Manufacture of fabricated metal products, except machinery and equipment	0.00	0.04	0.04	0.02	0.05	0.07	0.05	0.02	0.07	0.02	0.03	0.06
Manufacture of electronic parts and components	0.95	0.01	0.96	1.33	-1.07	0.25	0.82	-0.30	0.51	0.94	-0.26	0.68
Manufacture of computers, electronic and optical products	0.32	-0.10	0.22	0.41	-0.20	0.22	0.18	-0.15	0.03	0.27	-0.13	0.14
Manufacture of electrical equipment	0.02	0.00	0.02	-0.02	0.06	0.04	0.01	-0.01	0.01	0.01	0.00	0.02
Manufacture of machinery and equipment	0.06	0.03	0.09	0.07	-0.04	0.03	-0.02	0.08	0.06	0.03	0.04	0.07
Manufacture of motor vehicles, trailers and semi-trailers	0.04	-0.02	0.01	0.02	0.00	0.02	-0.01	0.02	0.02	0.02	0.00	0.02
Manufacture of other transport equipment	0.02	-0.02	0.00	-0.02	0.03	0.01	0.00	0.01	0.02	0.01	0.00	0.01
Manufacture of furniture	0.00	-0.01	-0.01	0.00	-0.01	0.00	0.00	0.01	0.00	0.00	0.00	0.00
Other manufacturing	0.04	-0.03	0.01	0.00	0.02	0.02	0.03	0.01	0.03	0.03	-0.01	0.02
									0.87	1.90	-0.70	1.20

Table A.2. Contributions to overall productivity growth by manufacturing sub-sectors in South Korea, 1998–2018

Manufacturing sub-sector	1998–2007 (average, percentage points)			2008–2010 (average, percentage points)			2011–2018 (average, percentage points)			1998–2018 (average, percentage points)		
	Intra-industry productivity growth effect (1)	Allocation effect (2)	Total (3) = (1) + (2)	Intra-industry productivity growth effect (1)	Allocation effect (2)	Total (3) = (1) + (2)	Intra-industry productivity growth effect (1)	Allocation effect (2)	Total (3) = (1) + (2)	Intra-industry productivity growth effect (1)	Allocation effect (2)	Total (3) = (1) + (2)
Manufacture of food products, beverages and tobacco	0.12	-0.04	0.08	0.02	0.03	0.05	0.06	0.02	0.08	0.08	-0.01	0.08
Manufacture of textiles, wearing apparel, leather and related products	0.18	-0.15	0.03	0.10	-0.03	0.07	0.11	-0.09	0.02	0.14	-0.11	0.03
Manufacture of wood and paper products, and printing	0.07	-0.03	0.05	0.07	-0.04	0.04	0.05	0.00	0.04	0.06	-0.02	0.04
Manufacture of chemical, rubber, plastics, fuel products and other non-metallic mineral products	0.61	-0.24	0.36	0.33	0.08	0.41	0.31	-0.04	0.27	0.46	-0.12	0.34
Manufacture of basic metals and fabricated metal products, except machinery and equipment	0.35	-0.01	0.34	0.28	0.07	0.35	0.14	-0.02	0.12	0.26	0.00	0.26
Manufacture of computer, electronic and optical products	0.59	-0.02	0.57	0.64	0.17	0.81	0.63	-0.02	0.61	0.61	0.01	0.62
Manufacture of electrical equipment	0.14	-0.03	0.12	0.26	-0.03	0.23	-0.01	0.09	0.08	0.10	0.02	0.12
Manufacture of machinery and equipment n.e.c.	0.17	-0.03	0.14	0.15	0.03	0.18	0.22	-0.07	0.16	0.18	-0.03	0.15
Manufacture of transport equipment	0.32	-0.06	0.26	0.37	-0.12	0.25	0.17	-0.11	0.06	0.27	-0.09	0.18
Manufacture of furniture; other manufacturing; repair and installation of machinery and equipment	0.06	-0.03	0.04	0.05	-0.04	0.01	0.04	0.00	0.04	0.05	-0.02	0.04
Total manufacturing	**3.02**	**-1.05**	**1.97**	**1.95**	**0.45**	**2.40**	**1.67**	**-0.19**	**1.49**	**2.35**	**-0.50**	**1.85**

Table A.3. Korea: changes in relative size of manufacturing sub-sectors, 1998–2020

Manufacturing sub-sector	Change, 1998–2007, percentage points			Change, 2008–2010, percentage points			Change, 2011–2018, percentage points			Change, 1998–2018, percentage points		
	Output shares	Employment shares	Relative output prices	Output shares	Employment shares	Relative output prices	Output shares	Employment shares	Relative output prices	Output shares	Employment shares	Relative output prices
Food products, beverages and tobacco	-0.45	-0.42	-11.91	-0.01	-0.04	2.24	0.11	0.10	-1.57	-0.40	-0.38	-9.57
Textiles, wearing apparel, leather and related products	-0.87	-1.66	-10.92	0.05	-0.07	4.71	-0.35	-0.24	0.11	-1.18	-2.09	-3.91
Wood and paper products, and printing	-0.26	-0.10	-2.27	-0.02	-0.06	-0.19	0.00	0.01	6.78	-0.32	-0.23	6.75
Chemical, rubber, plastics, fuel products and other non-metallic mineral products	-1.29	-0.31	-7.49	-0.08	0.02	-6.36	-0.77	0.15	-8.16	-1.58	-0.21	-10.21
Basic metals and fabricated metal products, except machinery and equipment	0.75	0.23	-3.38	-0.24	0.09	-20.16	-0.93	-0.01	-2.57	0.23	0.23	-7.19
Manufacture of computer, electronic and optical products	1.25	N/A	-2.39	1.62	0.05	10.13	1.53	-0.42	1.34	4.29	N/A	2.75
Manufacture of electrical equipment	0.29	N/A	2.64	0.33	0.04	-7.86	-0.05	0.05	-1.87	0.63	N/A	2.77
Manufacture of machinery and equipment n.e.c.	0.60	0.15	-7.77	0.14	0.07	-2.04	0.17	0.08	-0.76	0.97	0.32	-7.23
Transport equipment	0.78	0.09	-9.59	0.23	0.01	10.86	-1.04	-0.20	-2.06	-0.01	-0.13	-17.17
Furniture; other manufacturing; repair and installation of machinery and equipment	-0.06	-0.21	-9.09	-0.02	-0.01	-2.57	0.11	0.09	8.89	-0.02	-0.16	-1.20
Total manufacturing	0.75	-2.04	-6.21	2.01	0.09	-0.89	-1.22	-0.39	-2.05	2.63	-2.69	-6.56

Note: N/A, not available.
Source: Authors' computation, based on data from OECD (2020). Structural Analysis Database (STAN) and Korea Productivity Center.

Table A.4. Contributions of manufacturing sub-sectors to overall productivity growth in the United States, 1998–2020

Manufacturing sub-sector	1998–2007 (average, percentage points)			2008–2010 (average, percentage points)			2011–2019 (average, percentage points)			1998–2019 (average, percentage points)			2020 (percentage points)		
	Intra-industry productivity growth effect	Allocation effect	Total	Intra-industry productivity growth effect	Allocation effect	Total	Intra-industry productivity growth effect	Allocation effect	Total	Intra-industry productivity growth effect	Allocation effect	Total	Intra-industry productivity growth effect	Allocation effect	Total
Manufacture of food products, beverages and tobacco	0.02	-0.01	0.01	-0.03	0.11	0.08	-0.02	-0.07	-0.09	0.00	0.01	0.01	-0.03	0.13	0.10
Manufacture of textiles	0.01	-0.02	-0.01	0.00	-0.01	-0.01	0.00	0.00	0.00	0.01	-0.01	-0.01	0.00	0.00	0.00
Manufacture of wearing apparel	0.01	-0.02	-0.02	0.01	-0.01	0.00	0.00	0.00	0.00	0.00	-0.01	-0.01	0.01	-0.01	0.00
Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials	0.01	-0.01	0.00	0.01	-0.03	-0.01	0.00	0.00	0.00	0.01	-0.01	0.00	0.01	0.01	0.02
Manufacture of paper and paper products	0.01	-0.02	-0.01	0.00	0.01	0.01	0.00	0.00	0.01	0.00	-0.01	-0.01	0.01	0.00	0.01
Manufacture of printing and reproduction of recorded media	0.02	-0.02	0.00	0.01	-0.03	-0.02	0.00	-0.01	-0.01	0.01	-0.02	-0.01	0.02	-0.01	0.00
Manufacture of coke and refined petroleum products	0.02	0.04	0.07	-0.03	-0.04	-0.06	0.00	-0.01	-0.01	0.01	0.01	0.02	0.06	-0.26	-0.21
Manufacture of chemical products	0.09	-0.06	0.03	0.01	0.09	0.10	-0.03	0.00	-0.03	0.03	-0.01	0.02	0.11	0.03	0.14
Manufacture of rubber and plastics products	0.02	-0.03	-0.01	0.01	-0.01	0.00	0.00	0.02	0.02	0.01	-0.02	0.00	0.02	0.00	0.02
Manufacture of other non-metallic mineral products	0.00	0.00	0.00	0.00	-0.03	-0.02	0.00	0.00	0.01	0.00	0.00	0.00	0.02	0.01	0.02
Manufacture of basic metals	0.02	-0.02	0.00	0.03	-0.06	-0.03	0.02	0.00	0.02	0.02	-0.02	-0.01	0.11	-0.12	-0.01
Manufacture of fabricated metal products, except machinery and equipment	0.02	-0.03	-0.01	-0.01	-0.02	-0.03	0.00	-0.02	-0.02	0.00	-0.01	-0.01	-0.01	0.00	-0.01
Manufacture of computer, electronic and optical products	0.45	-0.48	-0.03	0.24	-0.20	0.04	0.07	0.00	0.08	0.27	-0.28	-0.01	0.05	0.05	0.10
Manufacture of electrical equipment	0.01	-0.02	-0.01	0.01	-0.01	0.00	0.00	-0.08	-0.08	0.01	-0.01	0.00	0.00	0.00	0.00
Manufacture of machinery and equipment n.e.c.	0.04	-0.05	-0.01	0.03	-0.02	0.00	-0.01	0.00	-0.01	0.02	-0.02	0.00	0.00	-0.01	0.00
Manufacture of transport equipment	0.12	-0.11	0.01	0.02	-0.07	-0.06	0.03	0.01	0.04	0.07	-0.06	0.01	-0.07	-0.05	-0.12
Manufacture of furniture	0.00	-0.01	0.00	0.00	-0.02	-0.02	0.00	0.00	0.00	0.00	-0.01	0.00	0.00	0.00	0.00
Other manufacturing	0.03	-0.02	0.00	0.05	-0.02	0.03	0.00	0.00	0.00	0.02	-0.02	0.00	0.09	-0.01	0.07
Total manufacturing	0.89	-0.90	-0.01	0.49	-0.47	0.01	0.04	-0.01	0.03	0.49	-0.50	-0.01	0.44	-0.29	0.14

Table A.5. Contributions of manufacturing sub-sectors to overall productivity growth in Germany, 1998–2017

Manufacturing sub-sector	1998–2007 (average, percentage points)			2008–2010 (average, percentage points)			2011–2017 (average, percentage points)			1998–2017 (average, percentage points)		
	Intra-industry productivity growth effect	Allocation effect	Total	Intra-industry productivity growth effect	Allocation effect	Total	Intra-industry productivity growth effect	Allocation effect	Total	Intra-industry productivity growth effect	Allocation effect	Total
Food products, beverages and tobacco	0.00	0.01	0.01	0.12	-0.12	0.01	0.02	0.02	0.04	0.03	-0.01	0.02
Textiles, wearing apparel, leather and related products	0.01	-0.02	-0.01	0.01	-0.02	-0.01	0.01	-0.01	0.00	0.01	-0.02	-0.01
Wood and paper products, and printing	0.03	-0.04	-0.01	0.01	-0.05	-0.04	0.02	-0.02	0.00	0.02	-0.03	-0.01
Chemical, rubber, plastics, fuel products and other non-metallic mineral products	0.11	-0.04	0.07	0.20	-0.16	0.04	0.06	0.03	0.09	0.11	-0.03	0.07
Basic metals and fabricated metal products, except machinery and equipment	0.10	0.01	0.11	-0.02	-0.13	-0.15	0.05	0.02	0.07	0.06	-0.01	0.05
Manufacture of computer, electronic and optical products	0.08	-0.03	0.06	-0.10	0.01	-0.09	0.03	0.02	0.05	0.04	-0.01	0.03
Manufacture of electrical equipment	0.03	-0.01	0.02	0.10	-0.04	0.06	0.03	-0.01	0.02	0.04	-0.02	0.02
Manufacture of machinery and equipment n.e.c.	0.12	0.00	0.12	0.01	-0.08	-0.07	0.09	0.04	0.13	0.09	0.00	0.09
Transport equipment	0.17	-0.01	0.16	0.14	-0.11	0.03	0.28	0.03	0.31	0.20	-0.01	0.19
Furniture; other manufacturing; repair and installation of machinery and equipment	0.05	-0.01	0.03	0.01	0.01	0.02	0.04	0.00	0.03	0.04	-0.01	0.03
Total manufacturing	0.71	-0.15	0.56	0.42	-0.63	-0.21	0.66	0.07	0.73	0.65	-0.14	0.50

Source: OECD (2020). Structural Analysis Database (STAN).

Table A.6. Contributions of manufacturing sub-sectors to overall productivity growth in the UK, 1998–2020

Manufacturing sub-sector	1998–2007 (average, percentage points)			2008–2010 (average, percentage points)			2011–2019 (average, percentage points)			1998–2019 (average, percentage points)			2020 (percentage points)		
	Intra-industry productivity growth effect	Allocation effect	Total	Intra-industry productivity growth effect	Allocation effect	Total	Intra-industry productivity growth effect	Allocation effect	Total	Intra-industry productivity growth effect	Allocation effect	Total	Intra-industry productivity growth effect	Allocation effect	Total
Manufacture of food products, beverages and tobacco	0.09	-0.12	-0.03	-0.03	0.03	0.00	0.01	-0.04	-0.03	0.04	-0.06	-0.03	0.08	-0.03	0.05
Manufacture of textiles, wearing apparel and leather products	0.09	-0.14	-0.05	0.05	-0.05	0.00	0.02	-0.01	0.00	0.05	-0.07	-0.02	0.04	-0.05	-0.02
Manufacture of wood and of products of wood and cork, except furniture	0.01	-0.01	0.00	-0.01	-0.01	-0.01	0.01	0.00	0.01	0.01	-0.01	0.00	0.01	-0.01	0.00
Manufacture of paper and paper products	0.03	-0.04	-0.01	0.03	-0.01	0.02	0.00	-0.01	0.00	0.02	-0.02	-0.01	0.06	-0.05	0.01
Printing and reproduction of recorded media	0.04	-0.04	0.00	0.01	-0.03	-0.02	0.01	-0.02	-0.01	0.03	-0.03	-0.01	0.02	-0.05	-0.03
Manufacture of coke and refined petroleum products	0.00	0.00	0.00	0.02	0.00	0.02	0.02	-0.01	0.00	0.01	-0.01	0.00	0.00	-0.06	-0.07
Manufacture of chemicals and chemical products	0.06	-0.12	-0.06	0.03	-0.04	-0.02	0.05	-0.04	0.01	0.05	-0.08	-0.03	0.17	-0.08	0.09
Manufacture of basic pharmaceutical products and pharmaceutical preparations	0.07	-0.05	0.02	0.00	0.04	0.04	-0.03	0.00	-0.03	0.02	-0.02	0.00	0.12	0.01	0.12
Manufacture of rubber and plastic products	0.05	-0.06	-0.02	0.01	-0.03	-0.02	0.01	-0.01	0.00	0.02	-0.03	-0.01	0.05	-0.04	0.01
Manufacture of other non-metallic mineral products	0.02	-0.03	-0.01	-0.01	-0.02	-0.02	0.01	-0.01	0.00	0.01	-0.02	-0.01	0.02	-0.02	0.00
Manufacture of basic metals	0.01	-0.03	-0.02	-0.04	0.02	-0.01	0.01	-0.01	0.00	0.00	-0.02	-0.01	0.03	-0.01	0.02
Manufacture of fabricated metal products, except machinery and equipment	0.04	-0.07	-0.03	0.00	-0.01	-0.01	0.02	-0.01	0.01	0.03	-0.04	-0.01	0.04	-0.06	-0.02
Manufacture of computer, electronic and optical products	0.12	-0.16	-0.04	0.09	-0.05	0.05	0.02	-0.02	0.00	0.07	-0.09	-0.01	-0.03	0.01	-0.02
Manufacture of electrical equipment	0.04	-0.06	-0.02	-0.01	0.01	-0.01	0.01	-0.02	-0.01	0.02	-0.03	-0.01	0.00	-0.01	0.00
Manufacture of machinery and equipment n.e.c.	0.11	-0.13	-0.03	-0.03	0.01	-0.02	0.00	0.00	0.00	0.04	-0.06	-0.02	-0.04	-0.06	-0.10
Manufacture of motor vehicles, trailers and semi-trailers	0.05	-0.08	-0.04	0.06	-0.03	0.04	0.01	0.02	0.03	0.03	-0.03	0.00	-0.13	-0.01	-0.14
Manufacture of other transport equipment	0.07	-0.07	0.01	-0.08	0.04	-0.04	0.00	0.01	0.01	0.02	-0.02	0.00	-0.08	-0.01	-0.09
Manufacture of furniture	0.01	-0.02	0.00	0.01	-0.03	-0.01	0.00	0.00	0.00	0.01	-0.01	0.00	0.01	-0.04	-0.03
Other manufacturing	0.04	-0.04	0.00	0.01	-0.01	0.00	0.00	-0.01	0.00	0.02	-0.02	0.00	0.01	0.01	0.01
Repair and installation of machinery and equipment	0.02	-0.03	-0.01	0.03	-0.02	0.02	-0.01	0.01	0.00	0.01	-0.01	0.00	0.07	-0.02	0.04
Total manufacturing	0.99	-1.34	-0.34	0.16	-0.19	-0.03	0.16	-0.17	-0.02	0.54	-0.70	-0.17	0.53	-0.70	-0.16

Manufacturing sub-sector	1998–2007 (average, percentage points)			2008–2010 (average, percentage points)			2011–2017 (average, percentage points)			1998–2017 (average, percentage points)		
	Intra-industry productivity growth effect	Allocation effect	Total	Intra-industry productivity growth effect	Allocation effect	Total	Intra-industry productivity growth effect	Allocation effect	Total	Intra-industry productivity growth effect	Allocation effect	Total
Manufacture of food products, beverages and tobacco	0.07	-0.04	0.03	0.06	-0.07	-0.02	0.03	0.02	0.05	0.05	-0.02	0.03
Manufacture of textiles, wearing apparel, leather and related products	0.03	-0.05	-0.02	0.00	-0.02	-0.03	0.01	-0.01	0.00	0.02	-0.03	-0.01
Manufacture of wood and paper products, and printing	0.02	-0.03	0.00	0.01	-0.04	-0.03	0.02	-0.01	0.00	0.02	-0.02	-0.01
Manufacture of chemical, rubber, plastics, fuel products and other non-metallic mineral products	0.12	-0.08	0.05	0.00	-0.12	-0.12	0.11	-0.05	0.06	0.10	-0.07	0.03
Manufacture of basic metals and fabricated metal products, except machinery and equipment	0.05	-0.03	0.03	0.04	-0.08	-0.04	0.02	-0.01	0.01	0.04	-0.03	0.01
Manufacture of computer, electronic and optical products	0.03	-0.04	-0.01	0.04	-0.06	-0.03	0.00	0.00	0.00	0.02	-0.03	-0.01
Manufacture of electrical equipment	0.01	-0.02	-0.01	0.01	-0.02	-0.01	0.01	-0.01	0.00	0.01	-0.01	-0.01
Manufacture of machinery and equipment n.e.c.	0.03	-0.02	0.02	0.01	-0.05	-0.04	0.01	-0.01	0.00	0.02	-0.02	0.00
Manufacture of transport equipment	0.07	-0.04	0.03	0.07	-0.08	-0.01	0.06	-0.03	0.02	0.06	-0.04	0.02
Manufacture of furniture; other manufacturing; repair								-0.03	0.02	0.05	-0.02	0.02
Total manufacturing								-0.12	0.17	0.38	-0.30	0.08

Table A.7.Contributions of manufacturing sub-sectors to overall productivity growth, 1998–2017 in France

Table A.8. China: Productivity growth decomposition, excluding the real estate sector, 1998–2018

Economic sector	All sectors			Excluding real estate		
	Contribution to productivity growth (1998–2018, average, percentage points)			Contribution to productivity growth (1998–2018, average, percentage points)		
	Intra-industry productivity growth effect (1)	Allocation effect (2)	Total (3) = (1) + (2)	Intra-industry productivity growth effect (1)	Allocation effect (2)	Total (3) = (1) + (2)
Agriculture, forestry and fishing	0.73	-0.26	0.47	0.77	-0.29	0.49
Mining and quarrying	0.49	-0.17	0.32	0.52	-0.19	0.33
Manufacturing	2.66	-0.17	2.49	2.80	-0.19	2.61
Electricity, gas and water supply; sewerage, waste management and remediation activities	0.30	-0.05	0.25	0.32	-0.06	0.26
Construction	0.43	0.15	0.58	0.46	0.16	0.61
Wholesale and retail trade; repair of motor vehicles and motorcycles	0.73	0.25	0.97	0.76	0.26	1.02
Transportation and storage	0.55	0.16	0.71	0.58	0.16	0.75
Financial intermediation, real estate, renting and business activities	0.69	0.52	1.21	0.43[1/]	0.22[1/]	0.65[1/]
Community, social and personal services	0.93	0.78	1.71	0.98	0.82	1.80
Whole economy	7.51	1.21	8.72	7.62	0.89	8.51

Note: Decomposition based on output per worker measures of productivity. [1/] Excluding real estate sector.
Source: Authors' computation, based on data from APO Productivity Database 2020 Ver.1.

Table A.9. South Korea: Productivity growth decomposition of 'Market sectors', 1998–2018

Economic sector	All sectors			'Market' sectors		
	Contribution to productivity growth (1998–2018, average, percentage points)			Contribution to productivity growth (1998–2018, average, percentage points)		
	Intra-industry productivity growth effect (1)	Allocation effect (2)	Total (3) = (1) + (2)	Intra-industry productivity growth effect (1)	Allocation effect (2)	Total (3) = (1) + (2)
Agriculture, forestry and fishing	0.15	-0.11	0.04	0.19	-0.11	0.08
Mining and quarrying	0.01	-0.01	0.00	0.01	-0.01	0.00
Manufacturing	2.35	-0.50	1.85	3.06	-0.45	2.61
Electricity, gas and water supply; sewerage, waste management and remediation activities	0.36	-0.22	0.13	0.47	-0.28	0.19
Construction	0.31	-0.10	0.21	0.41	-0.09	0.32
Wholesale and retail trade; repair of motor vehicles and motorcycles	0.60	-0.11	0.49	0.78	-0.08	0.70
Transportation and storage	0.22	-0.02	0.20	0.29	0.00	0.29
Accommodation and food service activities	0.16	-0.02	0.14	0.21	0.00	0.21
Information and communication	0.19	0.13	0.31	0.24	0.20	0.44
Financial and insurance activities	0.44	-0.07	0.37	0.58	-0.05	0.53
Real estate activities	0.39	0.06	0.44	N/A	N/A	N/A
Professional, scientific and technical activities	0.25	0.14	0.39	0.33	0.22	0.55
Administrative and support service activities	0.08	0.13	0.21	0.10	0.19	0.30
Public administration and defence; compulsory social security	0.34	0.08	0.42	N/A	N/A	N/A
Education	0.28	0.06	0.34	N/A	N/A	N/A
Human health and social work activities	0.08	0.24	0.32	N/A	N/A	N/A
Arts, entertainment, recreation and other services	0.11	0.03	0.14	0.15	0.06	0.20
Whole economy	6.32	-0.29	6.04	6.82	-0.40	6.42

Note: N/A, not applicable.
Source: Authors' computation, based on data from OECD (2020). Structural Analysis Database (STAN) and Korea Productivity Center.

Table A.10. Taiwan: Productivity growth decomposition of 'Market sectors', 1998–2019

Economic sector	All sectors			'Market' sectors		
	Contribution to productivity growth (1998–2019, average, percentage points)			Contribution to productivity growth (1998–2019, average, percentage points)		
	Intra-industry productivity growth effect (1)	Allocation effect (2)	Total (3) = (1) + (2)	Intra-industry productivity growth effect (1)	Allocation effect (2)	Total (3) = (1) + (2)
Mining and quarrying	0.00	-0.01	-0.01	0.00	-0.01	-0.01
Manufacturing	1.90	-0.70	1.20	2.32	-0.67	1.65
Electricity, gas, steam and air conditioning supply	0.05	-0.05	0.00	0.06	-0.05	0.01
Water supply; sewerage, waste management and remediation activities	0.02	0.01	0.02	0.02	0.01	0.03
Construction	0.03	-0.02	0.01	0.03	-0.01	0.03
Wholesale and retail trade; repair of motor vehicles and motorcycles	0.54	0.05	0.59	0.65	0.17	0.82
Transportation and storage	0.14	-0.09	0.05	0.17	-0.09	0.08
Accommodation and food service activities	-0.02	0.14	0.12	-0.02	0.18	0.16
Information and communication	0.21	-0.07	0.13	0.25	-0.07	0.18
Financial and insurance activities	0.19	-0.04	0.15	0.24	-0.01	0.23
Real estate activities	0.27	-0.01	0.26	N/A	N/A	N/A
Professional, scientific and technical activities	0.02	0.07	0.09	0.03	0.10	0.13
Administrative and support service activities	0.01	0.08	0.10	0.02	0.11	0.12
Education	-0.15	0.10	-0.05	N/A	N/A	N/A
Human health and social work activities	-0.04	0.17	0.14	N/A	N/A	N/A
Arts, entertainment and recreation	0.02	0.02	0.03	0.02	0.03	0.04
Other service activities	0.09	0.01	0.10	0.11	0.02	0.14
Whole economy	3.28	-0.35	2.93	3.90	-0.28	3.62

Note: N/A, not applicable. Source: Authors' computation, based on data from the Taiwan Statistical Bureau.

Table A.11: United States: Productivity growth decomposition of 'Market sectors', 1998–2019

Economic sector	All sectors			'Market' sectors		
	Contribution to productivity growth (1998–2019, average, percentage points)			Contribution to productivity growth (1998–2019, average, percentage points)		
	Intra-industry productivity growth effect (1)	Allocation effect (2)	Total (3) = (1) + (2)	Intra-industry productivity growth effect (1)	Allocation effect (2)	Total (3) = (1) + (2)
Agriculture, forestry and fishing	0.03	-0.04	0.00	0.05	-0.05	0.00
Mining and quarrying	0.06	-0.02	0.04	0.10	-0.03	0.07
Manufacturing	0.49	-0.50	-0.01	0.73	-0.67	0.06
Electricity, gas and water supply; sewerage, waste management and remediation activities	0.03	-0.02	0.01	0.05	-0.02	0.02
Construction	-0.05	0.13	0.08	-0.07	0.22	0.15
Wholesale trade	0.13	-0.05	0.09	0.20	-0.03	0.17
Retail trade	0.14	-0.09	0.04	0.21	-0.10	0.11
Transportation and storage	0.02	0.04	0.06	0.03	0.08	0.11
Accommodation and food service activities	0.01	0.07	0.07	0.01	0.12	0.13
Information and communication	0.33	-0.22	0.11	0.50	-0.30	0.20
Financial and insurance activities	0.13	0.04	0.17	0.20	0.10	0.30
Real estate and rental and leasing	0.20	0.08	0.27	N/A	N/A	0.00
Professional, scientific and technical activities	0.10	0.09	0.20	0.16	0.18	0.34
Management of companies and enterprises	0.02	0.03	0.05	0.03	0.06	0.08
Administrative and waste management services	0.06	0.02	0.07	0.08	0.04	0.13
Public administration and defence; compulsory social security	0.00	0.18	0.18	N/A	N/A	0.00
Education	0.00	0.04	0.03	N/A	N/A	0.00
Human health and social work activities	0.05	0.13	0.18	N/A	N/A	0.00
Arts, entertainment and recreation	0.01	0.01	0.02	0.02	0.02	0.04
Other service activities	-0.01	0.03	0.02	-0.02	0.06	0.04
Whole economy	1.75	-0.07	1.68	2.27	-0.31	1.96

Note: N/A, not applicable.
Source: Authors' computation, based on data from the US Bureau of Economic Analysis and Bureau of Labor Statistics.

Table A.12: Germany: Productivity growth decomposition of 'Market sectors', 1998–2017

Economic sector	All sectors			'Market' sectors		
	Contribution to productivity growth (1998–2017, average, percentage points)			Contribution to productivity growth (1998–2017, average, percentage points)		
	Intra-industry productivity growth effect (1)	Allocation effect (2)	Total (3) = (1) + (2)	Intra-industry productivity growth effect (1)	Allocation effect (2)	Total (3) = (1) + (2)
Agriculture, forestry and fishing	0.04	-0.03	0.01	0.06	-0.04	0.02
Mining and quarrying	0.01	-0.01	0.00	0.01	-0.02	0.00
Manufacturing	0.65	-0.14	0.50	0.92	-0.15	0.77
Electricity, gas, steam and air conditioning supply	0.07	-0.04	0.03	0.10	-0.05	0.05
Water supply; sewerage, waste management and remediation activities	0.03	0.00	0.03	0.04	0.00	0.04
Construction	0.10	-0.07	0.03	0.14	-0.08	0.05
Wholesale and retail trade; repair of motor vehicles and motorcycles	0.29	-0.08	0.20	0.41	-0.09	0.31
Transportation and storage	0.10	0.00	0.11	0.15	0.02	0.16
Accommodation and food service activities	0.04	0.00	0.04	0.06	0.00	0.06
Information and communication	0.07	0.05	0.12	0.09	0.09	0.18
Financial and insurance activities	0.17	-0.11	0.06	0.24	-0.14	0.10
Real estate activities	0.22	-0.01	0.21			
Professional, scientific and technical activities	-0.03	0.16	0.13	-0.04	0.25	0.20
Administrative and support service activities	0.04	0.12	0.17	0.06	0.19	0.25
Public administration and defence; compulsory social security	0.17	-0.08	0.10	N/A	N/A	N/A
Education	0.06	0.04	0.10	N/A	N/A	N/A
Human health activities	0.09	0.05	0.14	N/A	N/A	N/A
Residential care and social work activities	0.04	0.04	0.08	N/A	N/A	N/A
Arts, entertainment and recreation	0.02	0.01	0.03	0.03	0.02	0.05
Other service activities	0.03	-0.01	0.03	0.05	0.00	0.05
Activities of households as employers; undifferentiated goods- and services-producing activities of households for own use	0.01	0.00	0.00	0.01	0.00	0.01
Whole economy	2.23	-0.12	2.11	2.31	-0.03	2.29

Note: N/A, not applicable.
Source: OECD (2020). Structural Analysis Database (STAN).

Table A.13: United Kingdom: productivity growth decomposition of 'Market sectors', 1998–2019

Economic sector	All sectors			'Market' sectors		
	Contribution to productivity growth (1998–2019, average, percentage points)			Contribution to productivity growth (1998–2019, average, percentage points)		
	Intra-industry productivity growth	Allocation effect	Total	Intra-industry productivity growth	Allocation effect	Total
Agriculture, forestry and fishing	0.04	-0.05	-0.01	0.06	-0.08	-0.02
Mining and quarrying	-0.10	0.07	-0.02	-0.14	0.10	-0.04
Manufacturing	0.54	-0.70	-0.17	0.78	-1.06	-0.28
Electricity, gas, steam and air conditioning supply	0.01	0.00	0.02	0.02	0.00	0.02
Water supply; sewerage, waste management and remediation activities	-0.03	0.04	0.01	-0.04	0.05	0.01
Construction	-0.03	0.17	0.13	-0.04	0.22	0.17
Wholesale and retail trade; repair of motor vehicles and motorcycles	0.06	-0.01	0.05	0.09	-0.05	0.04
Transportation and storage	0.01	0.03	0.04	0.01	0.03	0.04
Accommodation and food service activities	-0.01	0.06	0.05	-0.01	0.07	0.06
Information and communication	0.56	-0.45	0.11	0.81	-0.67	0.14
Financial and insurance activities	0.08	0.07	0.15	0.11	0.08	0.19
Real estate activities	-0.23	0.30	0.07	N/A	N/A	0.00
Professional, scientific and technical activities	0.00	0.16	0.17	0.01	0.21	0.22
Administrative and support service activities	0.01	0.10	0.10	0.01	0.12	0.14
Public administration and defence; compulsory social security	0.09	-0.05	0.04	N/A	N/A	0.00
Education	-0.08	0.19	0.11	N/A	N/A	0.00
Human health and social activities	-0.02	0.19	0.17	N/A	N/A	0.00
Arts, entertainment and recreation	0.00	0.04	0.03	-0.01	0.05	0.05
Other service activities	-0.01	0.04	0.03	-0.02	0.06	0.04
Activities of households	0.01	0.00	0.00	0.01	0.00	0.00
Whole economy	0.89	0.19	1.08	1.65	-0.87	0.77

Note: N/A, not applicable.
Source: Authors' computation, based on data from the UK Office for National Statistics.

Table A.14: France: Productivity growth decomposition of 'Market sectors', 1998–2017.

Economic sector	All sectors			'Market' sectors		
	Contribution to productivity growth (1998–2017, average, percentage points)			Contribution to productivity growth (1998–2017, average, percentage points)		
	Intra-industry productivity growth effect (1)	Allocation effect (2)	Total (3) = (1) + (2)	Intra-industry productivity growth effect (1)	Allocation effect (2)	Total (3) = (1) + (2)
Agriculture, forestry and fishing	0.09	-0.08	0.01	0.13	-0.12	0.01
Mining and quarrying	0.01	-0.01	0.00	0.01	-0.01	0.00
Manufacturing	0.38	-0.30	0.08	0.57	-0.46	0.11
Electricity, gas, steam and air conditioning supply	0.06	-0.04	0.02	0.09	-0.06	0.03
Water supply; sewerage, waste management and remediation activities	0.02	0.01	0.03	0.02	0.02	0.04
Construction	0.16	0.02	0.17	0.24	0.02	0.26
Wholesale and retail trade; repair of motor vehicles and motorcycles	0.21	0.02	0.23	0.31	0.03	0.34
Transportation and storage	0.11	0.01	0.12	0.17	0.02	0.19
Accommodation and food service activities	0.06	0.03	0.09	0.09	0.05	0.14
Information and communication	0.08	0.06	0.14	0.11	0.10	0.21
Financial and insurance activities	0.13	-0.03	0.10	0.19	-0.04	0.15
Real estate activities	0.41	-0.02	0.39	N/A	N/A	N/A
Professional, scientific and technical activities	0.17	0.11	0.27	0.25	0.16	0.41
Administrative and support service activities	0.05	0.12	0.17	0.08	0.18	0.26
Public administration and defence; compulsory social security	0.25	-0.09	0.16	N/A	N/A	N/A
Education	0.12	0.01	0.13	N/A	N/A	N/A
Human health activities	0.14	0.03	0.17	N/A	N/A	N/A
Residential care and social work activities	0.09	0.02	0.12	N/A	N/A	N/A
Arts, entertainment and recreation	0.03	0.03	0.05	0.04	0.04	0.08
Other service activities	0.04	-0.01	0.03	0.06	-0.01	0.04
Activities of households as employers; undifferentiated goods- and services-producing activities of households for own use	0.00	0.00	0.00	0.01	0.00	0.00
Whole economy	2.59	-0.11	2.47	2.36	-0.10	2.27

Note: N/A, not applicable.
Source: OECD (2020). Structural Analysis Database (STAN).

Appendix IV. 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

Difference

Intra-industry growth effects

Economy	1998–2017
China (only real estate excluded)	0.10
France	-0.24
Germany	0.12
Korea	0.61
Taiwan	0.58
United States	0.47
United Kingdom	0.77

Allocation effects

Economy	1998–2017
China (only real estate excluded)	-0.41
France	0.02
Germany	0.02
Korea	-0.28
Taiwan	0.21
United States	-0.25
United Kingdom	-1.11

Total aggregate productivity growth

Economy	1998–2017
China (only real estate excluded)	-0.31
France	-0.22
Germany	0.14
Korea	0.19
Taiwan	0.62
United States	0.22
United Kingdom	-0.34

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