Lessons from Productivity Comparisons of Germany, Japan, and the United States

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Abstract

Germany, Japan and the United States are the three largest mature economies and set the productivity frontier in most industries. In aggregate, Germany caught up to US productivity by the 1990s but Japan remains well below the leaders and has the potential for faster growth. The article estimates the industry productivity leaders in the 1990s and whether lagging industries subsequently caught up to the leader. Germany lags the United States in some industries, like electronics, but has the advantage of worker training programs. US and German productivity slowed with the decline in global innovation. Japan lags behind US service sector productivity. Its manufacturing industries set the productivity frontier in the 1990s but have since fallen behind. Japan has low productivity small firms and lacks effective competition.

Economic growth provides broad and substantial benefits. When growth is strong, household incomes rise, and wages increase; it becomes much easier to balance budgets and to meet the needs of the poorest members of society. While overall economic growth does not guarantee that everyone in an economy will be better off, it is the single most important source of improvements in economic welfare.

Strong economic growth, in turn, comes from two sources, the growth in the workforce and growth in labour productivity.[2] The demographic trend in advanced economies has been towards lower birth rates leading to slower growth in the population and labour force (Table 1). An aging of the population compounds that trend as more workers move into retirement; and while immigration can provide an offsetting source of growth, it often generates social stresses and political resis-

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2 In this article labour productivity is measured by output per worker hour. That means changes over time in hours worked per worker will also impact output growth. There have been reductions in hours worked per worker, especially in Germany and Japan.

Table 1: Labour Force, Total Hour, Output and Labour Productivity in Advanced Economies (average annual rate of change)

	1970-1995	1995-2004	2004-2018	Change from 1970-95 to 2004-18
Labour Force				
Japan	1.0	0.0	0.2	**-0.8**
Germany	1.5	0.2	0.6	**-1.0**
United States	1.9	1.2	0.7	**-1.2**
G7	1.3	0.8	0.6	**-0.7**
Total Hours				
Japan	0.1	-1.0	-0.1	**-0.2**
Germany	-0.4	-0.3	0.7	**1.1**
United States	1.6	0.9	0.7	**-0.9**
G7	0.6	0.4	0.5	**-0.1**
GDP per hour (2015 constant prices)				
Japan	3.8	2.1	0.8	**-3.0**
Germany	2.9	1.5	0.9	**-2.1**
United States	1.5	2.5	1.1	**-0.3**
G7	2.4	2.2	0.9	**-1.5**
GDP (2015 constant prices)				
Japan	3.9	1.1	0.7	**-3.2**
Germany	2.5	1.3	1.5	**-0.9**
United States	3.1	3.4	1.9	**-1.2**
G7	3.0	2.5	1.5	**-1.6**

Source: Calculations based on OECD Stat data.

tance. Slower labour force growth leaves productivity as the main driver of overall economic advancement and, unfortunately, it too has slowed. Table 1 highlights a pervasive pattern of slower growth in in the workforce and labour productivity in the high-income economies of the OECD. Productivity improvement has been slow in the United States since the early 1970s, except for a period of resurgence in the late 1990s and early 2000s. Germany and Japan had faster growth through the 1970s, but their growth rates have also fallen sharply.

A comparison of the patterns of productivity growth in the three largest mature economies, the United States, Japan, and Germany, is the focus of this article. They are representative of the productivity frontier in their respective regions.[3] They also have comparable high-quality data on the growth of output, labour, and capital at the level of the total economy and individual industries. We will use that data to examine productivity changes in the three economies in the aggregate and subsectors. Looking at the three most important mature economies can cast light on the nature of the slowdown and provide a step towards disentangling the causes of the slowdown. There have been many efforts to understand why growth has been so slow in recent years, and while there is some suggestive and interesting evidence of what factors may be at work, there is no con-

3 We do not include China, even though it is now the largest economy in the world based on purchasing power parity (PPP). China is still a middle-income country whose growth is driven by a different phenomenon of raising overall productivity by shifting the workforce out of agriculture into industry and services and adopting (copying) technologies in standard use in higher productivity countries.

sensus explanation for the pattern of slow growth that is widespread both by country and by industry (Baily and Montalbano, 2016; Gordon and Sayed, 2019; and OECD, 2019a).[4] Another motivation for this line of research is that the cross-country comparisons may be helpful in identifying industries that have the potential for faster growth in the future.

The article proceeds as follows. In the first major section, we provide a background on productivity definitions and measurement approaches. In the second section, we report productivity results for the aggregate economy, industrial sectors, and manufacturing industries for Japan, US, and Germany. We then identify and analyze problem industries and draw on results from previous research. We conclude with a discussion of reasons for respective productivity performance in the three economies.

Benchmarking to Find Industries Where There is Potential for Faster Growth

Which industries have performed particularly poorly relative to past rates of growth or relative to the performance of similar industries in the comparable economies? Even though the slowdown is pervasive, it may be possible to identify industries where faster growth is possible. Policy may be able to facilitate faster growth, for example by encouraging capital investment, or technology innovations (R&D). Changing the regulatory environment may also result in stronger competition and restructuring that improves productivity.

The first strategy to identify industries with greater growth potential comes from looking at industry growth rates. If productivity growth has been negative for a period of years it is important to ask what is causing this regression of productivity. Another sign of the possibility of faster growth potential is an industry that experienced rapid growth in a past period but has slowed more recently. Has the past growth exhausted the possibilities for faster growth in the future, or is there potential for another wave of growth?

A second strategy for finding industries with greater growth potential makes use of a comparison of productivity levels across countries. Industries that have productivity levels below those of comparable countries have the potential to catch up. With total factor productivity, productivity convergence will occur as technologies and best business practices are diffused across countries. With labour productivity, greater capital investment can bring lagging industries up to, or closer to, the productivity frontier. This second approach is important because it provides a possible way to improve productivity that avoids debate about whether future innovations can foster faster growth. If another country has already achieved higher productivity, then the challenge is to find a way to adopt technology already in use. This approach is

4 There is an extensive literature on the slowdown. Other articles in this area include Andrews *et al.* (2016), Askenazy *et al.* (2016), Furman and Orszag (2018), and Gutierrez and Phillipon (2017).

particularly important for Japan which lags in overall productivity.

A caveat to the argument is that there may be natural barriers to achieving a higher productivity level in some economic activities[5]. Silicon Valley is hard to replicate. The United States also has advantages in its endowment of arable land and energy resources. Managers may be less skilled in some countries than in others. This caveat should not be overstated. As we have known since David Ricardo, differences in endowments can lead to differences in specialization and trade rather than the perpetuation of low productivity industries. Managers are mobile, indeed many of the best US CEOs come from other countries, or their parents did. Foreign direct investment (FDI) can bring proprietary technology or best practice business processes into a country.

Definitions of Productivity

In this article we use both labour productivity, calculated as real value added per hour worked, and total factor productivity (TFP). The measure of TFP, drawn from the OECD STAN database, is real value added per unit of combined capital and labour. We also take the TFP estimates provided to us by Jorgenson, Nomura and Samuels (2018) that use gross output per unit of combined capital, labour, energy, service inputs and materials.

An advantage of labour productivity at the aggregate level is that it links GDP growth and wage growth. GDP growth is roughly the sum of the growth rate of GDP per worker and growth in the number of hours worked (employment growth adjusted for changes in hours per worker). Growth in output per hour in the business sector is closely linked to the growth of real labour compensation.[6] In this analysis of labour productivity, we have mostly relied on a value-added concept of output, and the labour input is defined as the hours of all workers. The advantage of TFP is that it estimates the shift in the production function as a result of technological change and other improvements in production methods. Since we do not estimate the impact of changes in human capital directly, those are also included in TFP.

If output is measured at the aggregate level, or if it is measured by value added at the industry or firm level, there are only two inputs to production, capital and labour.[7] In that case, the growth rate of labour productivity (output per hour) is the sum of the growth of TFP plus the con-

5 The levels of productivity are compared in a single base year using PPP exchange rates for that year to translate outputs and inputs in euros or yen into dollars. (labour input is measured in worker hours). Productivity in each country then changes in years away from the base year according to real output and input changes relative to the base year. In other words, productivity levels are set in one single year and then each country's relative industry or aggregate productivity growth rates determine the levels away from the base year.

6 Exceptions to this pattern can result for changes in the aggregate share of labour compensation, variations in its distribution, or divergent price deflators for output and compensation (Sharpe and Uguccioni, 2017).

7 We have chosen not to adjust the labour input for quality changes. The available data suggest that labour quality, as measured by educational attainment, changes only slowly over time and has not been a major factor in the recent productivity slowdown. There are also unsettled issues about how to best adjust for labour quality.

tribution of capital deepening (the increase in capital per hour worked weighted by the share of capital in cost). This is a valuable decomposition, indicating whether, say, a decline in labour productivity growth stems from a drop in TFP growth or a decline in the contribution of capital.

Comparing levels of productivity across countries requires a way to compare output measured in different currencies. Sometimes foreign exchange rates are used for this purpose and that may work well to compare tradable goods. However, exchange rates fluctuate over time in ways that can give a distorted picture of relative productivities and many goods and most services are not traded. The approach favored by the OECD and others is to measure purchasing power parity (PPP) exchange rates to capture relative prices of comparable goods or services across countries. Finding accurate price comparisons and insuring comparability of products is a challenge and there are differing findings depending on how the comparisons are made. Taking account of taxes is one of the more difficult aspects of this task along with ensuring comparable quality of goods or services. Also, the price comparisons are typically made in a single year and then the PPP exchange rate is extrapolated to other years using relative industry price changes in the countries being compared. There is room for error in these comparisons. We use PPPs estimated by the University of Gröningen for Germany and Japan comparisons to the United States and we also use the PPPs for Japan developed by Jorgenson, Nomura, and Samuels (2018).

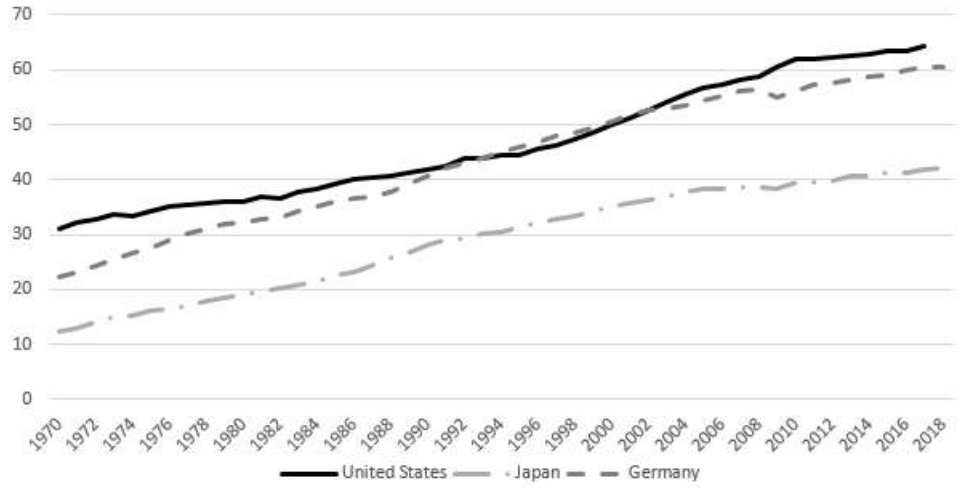
Productivity at the Aggregate Level

Chart 1 shows labour productivity at the aggregate level (GDP per hour worked) for Germany, Japan, and the United States from 1970 until the present, based on OECD data using purchasing power parity exchange rates for 2010. In 1970, both Japan and Germany had productivity levels that were only a fraction of the United States, but in subsequent years productivity growth was much higher and they reduced the gap[8]. Germany reached the US level of output per hour by the early 1990s and moved ahead of the United States briefly, before falling slightly behind at the end of the period. However, Germany has greatly reduced the number of hours worked per worker and so output per worker was only 73.7 per cent of the US level in 2017.

Japan also moved closer to the US productivity level before its financial crisis of the early 1990s. Subsequent growth has been slow, and the level of productivity remains well below that of the United States and Germany at the end of the period. Changes in hours worked per worker were also important in Japan. Historically, Japanese workers spent much longer at work than did American workers but over time this gap was reduced, and the hours per worker were similar in the two

8 The levels for 1970 for the three countries are as follows: United States: $30.9 US, Germany: $22.3 US, Japan: $12.5 US. Hence, Germany's aggregate productivity level was 0.72 relative to the United States in 1970, and Japan's aggregate productivity level was 0.40 relative to the US level in 1970.

Chart 1: GDP per Hour Worked in Japan, Germany and the United States, 1970-2018 (USD, constant prices, 2010 PPPs)



Source: OECD Stat

countries in 2018 based on OECD data.

A major theme of the economic growth literature of the 1970s and 80s was the "catchup hypothesis".[9] Regression analyses and growth theory suggested that the speed of productivity growth of a country depended on how far away it was from the productivity frontier, defined in most industries by the United States. Japan and Germany grew very rapidly indeed in the 1960s into the 1970s, as did some other countries. Paul Romer (1986) cast doubt on convergence by showing that if you include all the countries in the world, there is no systematic tendency for countries below the productivity frontier to catch up to the leaders. Romer argued that most countries did not have the technology needed to converge to the frontier. One can also argue that many countries lack the legal framework and market institutions to support catchup, and some do not have a workforce with the necessary skills and education. Subsequent empirical research on cross-country growth has found that catchup growth remains important even when looking at a broad sample of countries, but only after controlling for other growth determinants–conditional convergence (Barro and Sala-i-Martin 1998).

The data in Chart 1 are consistent with the story of catchup growth in both Japan and Germany in the years after World War II, some of it surely coming from postwar recovery and some from the diffusion of best-practice methods and technologies from the United States. By the 1990s, Germany had completed this catchup pro-

9 A good exploration of catchup is in Baumol, Batey Blackman, and Wolff (1989). An extensive bibliography is included in this book.

Table 2: Contribution from TFP and Capital Deepening to Labour Productivity Growth in the United States, Germany and Japan (average annual per cent or percentage point change)

	1985-1995	1995-2004	2004-2018
United States			
Labour Productivity	1.3	2.5	1.1
TFP	0.7	1.5	0.5
Capital Deepening	0.6	1.0	0.6
Japan*			
Labour Productivity	3.3	2.1	0.8
TFP	1.6	0.7	0.5
Capital Deepening	1.7	1.3	0.3
Germany			
Labour Productivity	2.5	1.5	0.9
TFP	1.6	0.8	0.6
Capital Deepening	0.9	0.7	0.3

Source: Calculations based on OECD Stat data. Labour Productivity is measured as value added per hour worked.

*Japan's last period is 2004-2017.

cess, and the level of aggregate labour productivity in the United States and Germany has been roughly the same for several decades. Japan, on the other hand, did not complete the catchup process and in recent years the gap has widened. An important puzzle is why Japan has not completed the catchup process. Japan is a mature economy that should have been able to converge to the productivity frontier. Indeed, as we show below, many Japanese industries did catch up or even set a new frontier but other industries still lag behind, as does the overall economy.

The productivity growth slowdown

Table 2 shows the pattern of both labour and total factor productivity growth for the three economies from 1985 through 2018, broken down into three time-periods.[10] As shown in the top panel, labour productivity growth in the United States was a modest 1.3 per cent a year from 1985 to 1995 split almost evenly between the contribution of TFP and the contribution of capital deepening. There was then a sharp acceleration, lasting about a decade, largely driven by faster growth in TFP, but there was also a greater rate of capital deepening. The post-2004 slowing of overall growth is evident in much smaller contributions from both capital deepening and TFP.

The second panel repeats the same calculations for Japan, where labour productivity growth was much more rapid than in the United States in 1985 to 1995 (catching up), but growth slowed in the second period and fell further to just under 0.8 per cent a year in the final period. Capital deepening and TFP both slowed sharply after 1995.

The same calculations for Germany are shown in the third panel and reveals a

10 The OECD data used here start in 1985 and end in 2018.

pattern similar to Japan. The three panels of Table 2 highlight the extent of the labour productivity growth slowdown in all three economies with a strong common element of very slow productivity growth since 2004. Both TFP and capital deepening contributed to growth over the full time-period, and there was a slowing in both elements after 1995. As in Japan and Germany, the contribution of capital deepening after 2004 was very small.[11]

Growth in TFP and the contribution of capital are connected. If technological change slows down, as reflected in slower TFP growth, it results in slow labour productivity directly, but it also reduces the incentive for businesses to invest. Alternatively, if some other factor causes a decline in investment, such as the global financial crisis, this may lead to a lower pace of TFP growth because newer technologies are often embedded in the new capital. The magnitude and pervasiveness of the growth slowdown suggests both causal effects have been at work.

The United States is notable for the sustained nature of its economic recovery from the 2009 recession that lowered the unemployment rate to historical lows. It received additional stimulus from a 2017 reduction in business taxes that was intended to encourage investment. While the tax cut contributed to continued growth in final demand and employment, there has been little evidence of a major impact on productivity growth, which continued at the average of the post-2004 period. As this is written, the Covid-19 virus has disrupted all economies and it will be some time before the underlying productivity growth trend is visible.

Productivity Growth by Broad Industry Category

Consistent labour productivity and TFP data by industry are available from the OECD Structural Analysis (STAN) database for the United States, Japan, and Germany. Japanese data are available from 1995 through 2016 but we have used data from the Japan Industrial Productivity (JIP) database to extend the sample back to 1991. We did not take the data back prior to 1995 for Japan for agriculture and construction because there was a wide discrepancy between the STAN data and the JIP data where they overlap.

Table 3 shows the results for labour productivity (value added per hour worked) for the three countries. The slowdown of productivity growth after 2004 has been widespread and easily visible in the industry data for all three countries. In Japan, there are only two industries, construction and real estate, that show faster productivity growth after 2004. Over the full period 1991 through 2016 for the business sector, labour productivity grows about a half percentage point faster in the United States than Japan and Germany. This is the result of faster growth prior to 2004, especially from 1995 through 2004. From 2004 through 2016, the annual rates of growth

11 A referee pointed out to us that Japan and Germany may have overinvested prior to 2004, which would have led to lower investment subsequently.

Table 3: Labour Productivity by Industry, United States, Japan, and Germany (average annual rate of change)

		United States				Japan				Germany			
		1991-1995	**1995-2004**	**2004-2016**	**1991-2016**	**1991-1995**	**1995-2004**	**2004-2016**	**1991-2016**	**1991-1995**	**1995-2004**	**2004-2016**	**1991-2016**
1	Agriculture, forestry and fishing	1.3	5.8	3.4	3.9	-	2.0	1.4	1.7*	-5.2	7.6	-1.0	1.4
2	Mining and quarrying	8.0	-0.3	2.2	2.2	-6.4	4.0	-7.1	-3.0	7.2	-0.6	2.2	2.0
3	Manufacturing	3.6	6.1	1.9	3.7	2.7	3.3	2.4	2.8	3.2	2.9	2.0	2.5
4	Utilities	1.3	0.5	-0.7	0.0	0.7	2.5	-3.5	-0.7	1.0	3.1	0.6	1.6
5	Construction	0.6	-0.7	-1.1	-0.7	-3.2	-1.2	0.9	-0.5	-1.0	0.5	0.1	0.1
6	Wholesale and retail trade	3.6	5.1	1.0	2.9	5.0	2.0	0.4	1.7	0.6	2.9	1.8	2.0
7	Transportation and storage	1.1	1.6	-0.1	0.7	1.4	-0.3	-0.8	-0.3	4.3	3.6	0.6	2.3
8	Information and communication	1.6	4.1	3.9	3.6	7.9	5.5	-0.2	3.2	5.3	4.7	3.4	4.2
9	Financial and insurance activities	1.6	4.1	1.3	2.4	0.6	1.1	0.3	0.6	1.3	-2.0	1.1	0.0
10	Real estate	3.4	0.7	2.0	1.7	-	1.6	0.3	0.9*	2.0	1.6	1.3	1.5
11	Professional, scientific and technical activities; administrative and support service activities	-0.7	1.5	0.6	0.7	2.7	3.8	1.7	2.6	0.2	-1.7	-1.3	-1.2
12	Community, social and personal services	-0.7	-0.2	0.1	-0.1	0.5	-0.1	-0.5	-0.2	1.8	0.6	0.4	0.7
	Non-agriculture business sector excluding real estate	**2.0**	**3.4**	**1.1**	**2.1**	**1.8**	**2.2**	**1.0**	**1.6**	**1.7**	**2.0**	**1.2**	**1.5**

Source: Calculations based on OECD Structural Analysis statistics (STAN). The growth rates shown for the private nonfarm business sector exclude agriculture and construction for all three countries. They differ from the data shown in Table 2, which are based on total GDP.

Note: 1995-2016 for starred industries in Japan.

are very similar in all three countries: 1.1 per cent in the United States, 1.0 in Japan and 1.2 per cent in Germany.

Looking at the results by industry reveals that all three economies saw declines in manufacturing productivity growth after 2004, but the decline is much sharper in the United States. This is partly the result of the ending of the surge in computer and semiconductor productivity in the 1990s and early 2000s, a surge that slowed after 2004. This industry has also moved large portions of its production overseas, making it a smaller fraction of manufacturing. Post-2004, Japan's manufacturing productivity growth rate has been the greatest, followed by Germany.

Productivity growth in wholesale and retail, as well as transportation and storage, has also been very slow in all three countries since 2004. The story of faster growth in earlier periods is now well-known as big box retailers and franchised smaller establishments displaced traditional retailers and integrated the wholesale function into their retail operations (Lewis *et al.*, 2001). Online retail is now changing the industry, but as yet this segment is not large enough to offset the decline in growth in bricks and mortar retailing.

The information and communications industry consists of publishing and broadcasting, telecommunications, information technology (including computer programming consultancy) and information service activities. This sector has benefit-

ted from advances in electronics and shows rapid growth in all three economies. Over the full period 1991-2016, the productivity gains were substantial across the three economies, but growth came to an abrupt end in Japan after 2004.

Productivity growth in the utilities industry has been very weak in the United States and Japan, zero in the former and negative in the latter over the full 1991-2016 period. In contrast, growth in Germany has been 1.6 per cent a year over the whole period, with rapid growth concentrated in 1995-2004. Utilities are heavily regulated in all three countries and have been impacted by shifting fuel prices and environmental concerns. Both Germany and Japan have shut down nuclear plants while the US industry has taken advantage of cheap natural gas. Growth slowed in Germany after 2004, but it turned negative in the United States, a puzzling result likely to be a consequence of regulation.

Financial and insurance activities in the United States have seen relatively strong productivity growth over the full period, with the strongest growth in 1995-2004, a period that included the early years of the real estate boom. Growth slowed after 2004, but still did a little better than in the other two economies. All three countries were impacted by financial cycles. The measurement of productivity in this industry is also difficult and the results should be viewed with caution.

Labour productivity growth in agriculture, forestry and fishing[12] has been much more rapid in the United States over the full time-period at 3.9 per cent a year, compared to 1.7 per cent in Japan[13] and 1.4 per cent in Germany. There is substantial volatility in the growth rates over shorter periods, which partly reflects weather patterns. Over the entire postwar period, productivity growth in US agriculture has been among the most rapid of all US industries, driven by advances in seeds, fertilizers, irrigation and other techniques. It may be that climate change will impact this industry in all three countries, but that is not yet evident in the productivity data through 2016.

Mining and quarrying saw good productivity growth in the United States and Germany but a decline in labour productivity in Japan. This industry is impacted by the depletion of the natural resource base, by the offsetting development of new technologies for extraction, and by regulation. In the US data, the period of fastest growth is prior to 1995. The fracking revolution is not yet evident in the most recent time-period.

Productivity in the remaining industries—real estate, professional services and community services—is difficult to measure and it is hard to see clear patterns in the reported data. The real estate boom and bust in the United States does not show up strongly in the productivity

12 Since agriculture is by far the most important part of the sector, the agriculture, forestry, and fishing industry will be henceforth referred to as the agriculture industry.

13 The STAN data for Japan are only available from 1995 to 2016.

14 http://www.csls.ca/ipm/38/Baily_Appendix.pdf.

growth data.

Table A1 in the on-line Data Appendix to this article[14] shows the comparable industry findings for total factor productivity. The TFP results are similar to those for labour productivity, particularly in showing the slowdown in growth after 2004. There are some differences, however. In Germany, the aggregate slowdown in TFP is very mild overall, and several industries—mining, construction (by a tiny amount), financial services, and professional services (a smaller TFP decline)—have stronger TFP growth after 2004. Community, social and personal services stay the same, while manufacturing's slowdown is modest. In the United States, the TFP slowdown is largest in agriculture and manufacturing. Mining, real estate, professional services, community, social and personal services all show somewhat faster growth after 2004, and construction has a slightly smaller rate of decline. In Japan, the post-2004 slowdown remains pronounced with a pattern of change similar to labour productivity.

Manufacturing Productivity

There is more industry detail available for the manufacturing sector than for service industries. The United States, Japan and Germany have the largest manufacturing sectors among developed economies, and we have seen the importance of manufacturing to the overall slowdown in productivity growth. It is worth looking in more detail at the manufacturing industries. Table 4 shows the labour productivity growth rates for the manufacturing sub-industries as given in the STAN data, basically 2-digit industries except that machinery is broken into electrical, electronic and optical equipment and machinery and equipment n.e.c. The comparable TFP growth figures are given in Appendix A2.[15] The data for Germany also ends in 2015, compared to 2016 for Japan and the United States, and there is no STAN data for Japan prior to 1995.

The data for Germany show relatively steady growth across the sub-industries within manufacturing over the full period from 1991 to 2015, although with a broad slowdown after 2004. To qualify this statement: machinery n.e.c. growth is negative after 2004, while food products and transportation equipment have faster growth after 2004, both in labour productivity and TFP (Table A2 in the on-line A Data Appendix). Even with these qualifications, it appears that German manufacturing companies have been able to improve operations year by year across a broad range of industries. There are not periods of very rapid growth (as in the United States in the 1990s). Post-2004, labour productivity growth and total factor productivity growth in Germany are the same, indicating very weak capital investment.

The United States and Japan had faster growth than Germany over the full period, with particular contributions from electrical and electronic equipment (which includes computers). The US sector has not seen consistent growth in other manufac-

15 The coke and refined petroleum industry is missing from the Germany panel because separate STAN data are not available for Germany.

Table 4: Labour Productivity in Manufacturing Industries in the United States, Japan, and Germany (average annual rate of change)

		United States				Japan			Germany			
		1991-1995	**1995-2004**	**2004-2016**	**1991-2016**	**1995-2004**	**2004-2016**	**1995-2016**	**1991-1995**	**1995-2004**	**2004-2015**	**1991-2015**
3a	Food, beverages and tobacco	4.6	-0.8	-0.1	0.4	-0.1	0.0	0.0	-0.9	-0.5	1.7	0.4
3b	Textiles, wearing apparel, leather and related	3.5	4.2	1.2	2.6	-0.5	0.3	-0.1	5.8	3.4	0.9	2.6
3c	Wood and paper , and printing†	-3.1	2.2	1.3	0.9	0.6	0.1	0.3	2.3	2.7	2.3	2.5
3d	Coke and refined petroleum	5.1	13.2	-1.0	5.1	-0.3	-0.9	-0.6	-	-	-	-
3e	Chemical and pharmaceuticals	3.0	3.9	0.9	2.3	2.5	1.5	1.9	8.1	4.7	0.9	3.5
3f	Rubber and plastics	1.4	4.7	0.3	2.0	-	-	-	4.5	2.3	1.3	2.2
3g	Other non-metallic minerals	3.1	2.0	-0.1	1.2	2.7	-0.3	1.0				
3h	Basic metals and fabricated metal products	2.3	2.7	0.4	1.6	0.9	0.3	0.5	3.2	2.4	0.7	1.8
3i	Electrical, electronic and optical equipment	14.6	15.5	6.9	11.2	10.4	7.3	8.7	3.7	5.6	3.7	4.4
3j	Machinery and equipment n.e.c.	0.1	2.0	0.5	1.0	1.8	3.1	2.6	3.9	1.6	-0.7	0.9
3k	Transport equipment	0.2	4.1	2.3	2.6	2.1	0.5	1.1	1.3	1.4	4.5	2.8
3l	Furniture; other manufacturing	0.7	3.7	1.3	2.1	-	-	-	2.0	3.4	0.7	1.9
	Manufacturing	**3.6**	**6.1**	**1.9**	**3.7**	**3.3**	**2.4**	**2.8**	**3.2**	**2.9**	**1.9**	**2.5**

Source: Calculations based on OECD Structural Analysis Statistics (STAN)

†Paper and paper products for Japan.

turing industries, and has had very slow growth since 2004. The story for Japan has been similar, with strong productivity growth in electrical and electronics and not strong growth elsewhere. Labour productivity growth and TFP growth in manufacturing in Japan have been faster than in the United States and Germany since 2004.

We turn now to the additional information that can be learned from using productivity levels as well as growth rates.

Problem Industries Identified Using Productivity Levels and Growth Rates

One means of diagnosing industries with a productivity problem is to focus on those where the level of productivity is below the frontier but where catch up is not occurring. Specifically, we will identify German and Japanese industries that were below the productivity level of the US industry (measured in PPP values) in 1994, but where the productivity growth rate 1995-2016 has been slower than in the United States. US industries with a similar problem can also be observed if their level of productivity was below either Japan or Germany but where the US industry was growing more slowly.[16] If there are "problem" industries, the next step is to identify

16 Studies from the McKinsey Global Institute used the approach of flagging industries with productivity below the level of the frontier industry. The methods are described in Baily and Solow (2001). The McKinsey studies generally did not look at productivity growth rates, however.

what the barriers are to industries achieving frontier-level productivity. In some cases, there may be a natural barrier as we noted earlier in this article. However, if the barrier to high productivity is the result of inefficient regulation, or problems in technology development, or lack of skills, or some other policy lever or constraint, then better future performance may be possible. The first step, therefore, is to identify lagging or problem industries.

Lagging Industries

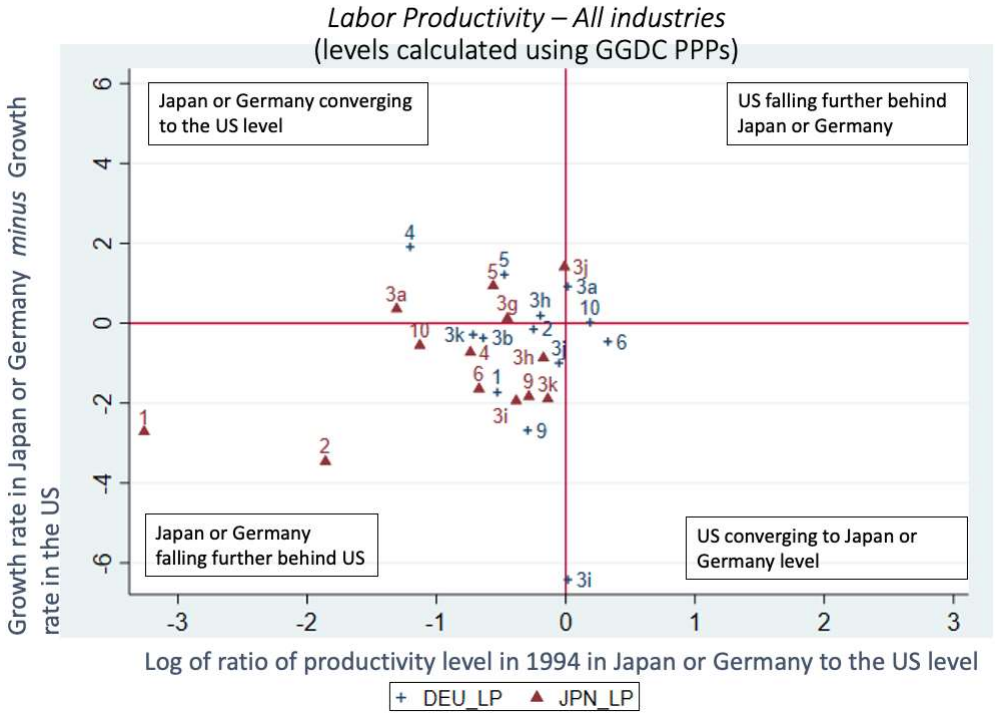
Using the results already presented for industry labour productivity growth rates, we calculate the rate of growth of each industry in Japan and each industry in Germany over the period 1995-2016 and compare it to the growth rate in the same industry in the United States. These growth-rate differentials are plotted on the vertical axis of the charts below, and the zero line indicates the same growth rate in two comparison countries. A positive number for the industry in either Japan or Germany means it grew faster than the US industry from 1995-2016. That may be a red flag for the US industry. A negative number is where the industry is growing more slowly than in the United States, implying a possible problem industry for either Japan or Germany or both.

On the horizontal axis of the chart, we plot the natural logarithm of the ratio of the level of labour productivity in Japan or Germany to the level of labour productivity in the United States. The comparisons of productivity levels are based on industry-specific PPPs for 1997 from the Gröningen Growth and Development Project (GGDC), which are then linked to our prior industry-level measures of labour productivity growth from the OECD (Tables 3 and 4). If the PPP-adjusted levels of labour productivity are the same in two countries, then the ratio is unity and log value is zero—this is the vertical axis in the figure. Points to the right of the zero axis line show industries where labour productivity was higher in either Japan or Germany relative to the United States in 1994. Points to the left show industries where productivity was higher in the United States.

The horizontal and vertical axes divide the industries into four quadrants. The upper left quadrant is where the US productivity level was higher, but growth was faster in Germany or Japan. This case indicates that the industry in Japan or in Germany was behind the US level of productivity but catching up—there was convergence to the US frontier productivity level. The lower right quadrant is where the US productivity level is lower than in either Germany or Japan but where the US industry is catching up. Thus, both the upper left and the lower right quadrants are consistent with the convergence hypothesis, where the industry that was below the frontier level of productivity was also catching up to the frontier.

The industries in the lower left quadrant or in the upper right quadrant are not converging to the frontier level of productivity among these three countries. These are industries that were below the most productive industry in 1994 but were falling further behind 1995-2016. The lower left quadrant is for problem industries either in

Chart 2: Industry Productivity Growth Differentials (1995-2016) against Productivity Levels (1990) Relative to the United States, Japan and Germany (All Industries, labour Productivity)



Source: Calculations based on GGDC PPPs and OECD STAN data.

Note: Major industry labels in table 3. Manufacturing industry labels (subpart 3) in table 4.

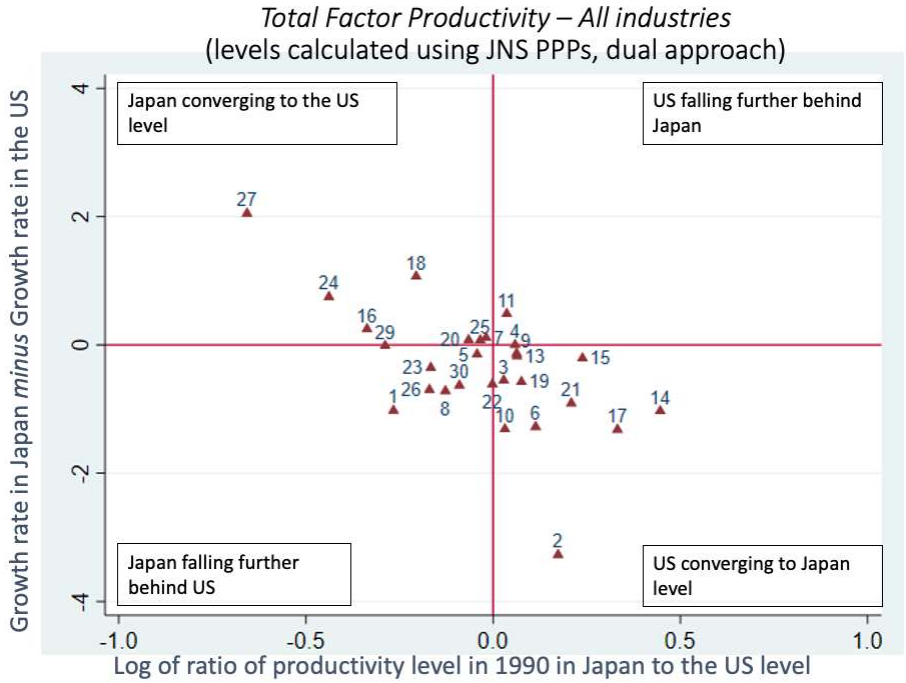
Japan or Germany. The upper right quadrant identifies problem industries in the US, industries that were below level of productivity in either Japan or Germany but were also growing more slowly.

Chart 2 shows the industry plots for manufacturing and non-manufacturing industries in the STAN data base. Industries in Japan are shown as triangles and industries in Germany as plusses. The observations are labeled with the industry numbers of Tables 3 and 4 for identification purposes. The labels 3a, 3b, etc., indicate manufacturing subindustries which are listed in Table 4.[17] The figures reveal that labour productivity in most industries in both Japan and Germany were computed to be below the level of productivity in the United States in 1994 (most points are to the left of the zero line). Some of the industries are in the upper quadrant, indicating they grew faster than the United States industry over the period 1995-2016 (they were converging), but many are in the lower quadrant, indicating they fell further behind.

In Germany, agriculture, finance and textiles are below the US level and falling

17 Even though they are in Table 4, they are part of manufacturing, which is industry 3, hence they are 3a, 3b and the rest.

Chart 3: Industry TFP Growth Differentials (1991-2016) against Productivity Levels (1990), Japan Relative to the United States



Source: Calculations based on JNS data.

Note: This chart is based on relative levels in 1990, rather than in 1994 as in the previous chart. Industry labels in Table A3 in the on-line Data Appendix.

behind. The same is true of transport equipment but that may be deceptive because the US industry includes aerospace. The German auto industry is very strong. Productivity in electrical and electronic equipment was on a par with the United States in 1994 but grew much more slowly after that. Germany is catching up in utilities and construction. Germany is ahead of the United States in trade but the United States is catching up. The food and beverage industry in the United States was on par with Germany in 1994, but grew more slowly post-1994.

Turning to Japan, there are many industries that are below the US level of productivity and falling behind. Agriculture and mining are way behind. Utilities, trade, finance are also falling further behind. Among manufacturing industries, these data suggest basic metals, electrical and electronic equipment, and transport equipment are also falling further behind.

Productivity Level and Growth Results from Jorgenson, Nomura and Samuels

A 2018 study by Jorgenson, Nomura and Samuels (JNS) developed their own matching industry-level production accounts for the United States and Japan covering 36 industries from 1955-2015. They also constructed a greatly expanded set of PPPs for 174 industries using unpublished EU-OECD data, a Japan-US bilat-

eral input-output table, and a Japanese survey comparing domestic and foreign prices.[18] JNS calculated their own productivity growth rates and levels for 36 industries in Japan. Although their data are proprietary, they have generously made them available. Since their analysis is structured around TFP estimation we have plotted the comparable figure to those shown in Chart 2 in terms of TFP, as shown in Chart 3.[19] The industry labels for this figure are shown in the Appendix Table A3.

Unlike the prior results, the JNS TFP data show strong evidence of convergence with 64 per cent of the industries falling in the upper left quadrant or the lower right quadrant. The JNS figures for TFP also show many industries where the United States was behind Japan at the start of the period (in 1990), all of them manufacturing sub-industries. All but two of these converged towards Japan over the period from 1990 to 2015. Despite the general pattern of convergence, there are six industries in Japan that were behind the United States in 1990 and fell further behind subsequently. These were agriculture, furniture, water transport, textile, finance and insurance, and other transport and storage.

In addition, mining, apparel, printing, primary metal and computer and electronic products started above the United States in 1990 but fell below by 2015. This is concerning for Japan, and furthermore, when the level of TFP in Japan was higher than in the United States in 1990, there is, on average, a decline in TFP growth over the subsequent period, 1990-2015. US industries in the lower right quadrant in the figure are catching up to Japan but this is happening in large part because of weak Japanese performance in industries that had been productivity leaders in 1990.

We also used the JNS data to calculate labour productivity for their industries, based on value added per hour worked. There is less convergence in the labour productivity estimates, which is surprising since capital accumulation has been seen in the literature as an important way in which convergence occurs to equalize labour productivity levels as countries develop. The lack of convergence in labour productivity surely reflects weakness in capital accumulation in Japan 1990-2015.

Reasons for German Productivity Performance

Influential economist Hans Werner Sinn (2006) has argued that Germany is (or was) the "laggard of Europe" and he describes Germany as a "bazaar" economy in which German companies produce goods in Eastern Europe, bring them back to Germany, add a prestige nameplate and then re-export them, earning high markups. If correct, this behavior would have under-

18 Details on the data calculations are provided in Jorgenson, Nomura, and Samuels (2018). Unfortunately, the data do not exist to extend the methodology to Germany.

19 JNS calculate TFP levels from gross output adjusting for all inputs, capital, labour, energy, materials and purchased services. This results in estimates of TFP growth that are smaller, scaled differently, than estimates from value added. That scaling difference does not impact the lessons to be learned from TFP performance. In their work, JNS provide productivity data back to 1955, however, the focus of this report is on more recent data and we will look particularly at the results from 1990 to 2015.

mined Germany's traditional strength in manufacturing. A few years later, Dustmann *et al.* (2014) argued that Germany had moved from sick man of Europe to superstar. They show the share of domestic value added in German manufacturing output has not declined in the way claimed by Sinn (2006).

There is greater agreement in the literature that German productivity growth has been weak, but there are a variety of explanations given for this. Elstner, Feld, and Schmidt (2016), in a report from the German Council of Economic Experts, argue that the main reason for slow productivity growth is that Germany has absorbed over three million workers since 2005, mostly from Eastern Europe and possessing comparatively low skill levels. They also argue that restructuring of value chains in manufacturing has come to an end. The 2016 OECD survey of the German economy also mentions the effect on productivity of integrating immigrants into the workforce. In addition, the OECD points to concerns about regulation, especially in services. Professional services, they say, are almost completely closed to outside competition. Schneider (2013) also points to the low productivity in the corporate services sector.

A study by the McKinsey Global Institute (2002) also stressed the role of regulation in depressing productivity in Germany and limiting competition, particularly in services. Regulation in Germany or in the EU also prevented some companies from achieving optimal scale.

Both Schneider and the OECD identify the low level of capital accumulation in Germany as a cause of weak labour productivity growth. Van Ark *et al.* (2009) point to concerns about the lack of accumulation of intangible capital in Germany. Low investment is only a proximate cause of productivity weakness and it is important to determine why companies are not investing at a higher rate.[20]

Van Ark, de Vries, and Erumban (2019) examine the contribution to productivity in the EU and in the United States from the production and use of digital technology, dividing the using industries into those that use the technology intensively and those that do not. They suggest a connection between digital technology and productivity growth for both regions, but their results for Germany do not indicate such a connection. They report (in Table 2 from their article) that the biggest contributions to the growth in German GDP per hour came from the *least* intensive digital-using industries both in the period 1996-2006 and in the period 2007-17.[21] The United States does show a connection between productivity growth and digital technology, so the two countries are different in this regard.

Takeaways for German Productivity Performance

In three industries, utilities, construc-

20 The McKinsey study (2002) reported that some German companies report that investing in additional capital (including IT capital) would not payoff because regulation prevented them from adjusting labour inputs.

21 Further, the decline in GDP per hour worked between 1996-2006 and 2007-17 occurred across all three industry types (the digital producing industry and the two using industries).

tion, and textiles, the German productivity levels are behind those in the United States but are catching up. Productivity growth in utilities since 2004 has been poor, but not as bad as in the United States. The industry is regulated, and Germany has committed to improving its emissions levels, but the transition is proving costly (Deloitte, 2015). Construction productivity growth has also been bad in all three countries. This is also the effect of regulation, plus measurement problems may be causing an understatement of growth. The textile industry in Germany uses high technology to compete globally whereas the US industry has largely migrated overseas leaving behind a specialty industry with high relative productivity (Int-Team Consulting, 2015).

Two German industries are falling further behind. Policy makers must decide the extent to which they wish to preserve agriculture at its current scale at the price of a significant productivity penalty. Similarly, underperformance occurs in the banking sector where small local banks are preserved despite their weak performance. Furthermore, bank regulation, which occurs at the EU level, has consistently failed to deal with problems in the larger banks (Larson, 2019).

We were not able to determine which industries absorbed the influx of immigrant labour, but construction and retail trade seem likely destinations. German productivity in the trade sector is strong partly because of leading companies that operate throughout Europe and globally (Edeka, Schwartz Group, Aldi, Metro). The industry is heavily regulated which has mixed effects on labour productivity. Restrictive opening hours concentrate shopping to a shorter time period and raise measured productivity at the expense of customer convenience.[22]

In general, German manufacturing industries compare favorably to their US and Japanese counterparts in both productivity levels and employment growth. The main exception is electrical and optical equipment. German manufacturing has developed high-tech products but does not have the same level of production of computer and related products.[23]

Chart 1 showed that Germany caught up to the US level of overall productivity some years ago. It fell behind somewhat during the 1990s when the US economy was spurred by the IT sector. Although Germany has innovative tech companies, there is no equivalent of Silicon Valley in Germany. Also, regulation in services is greater in Germany. On the other hand, the US economy has no equivalent of the German worker training programs. Despite differences in the industry pattern, slow productivity growth in Germany, as in the United States, surely derives from a broad slowing in productivity-enhancing innovation, as Gordon and Sayed (2019) have suggested.

22 Online retailing is growing in Germany but was not large over the time period shown in this study.

23 Transportation equipment has a lower level of productivity in Germany. Their auto industry is very strong but they do not have strength in aerospace for historical reasons.

Reasons for Japanese Productivity Performance

The literature also advances differing hypotheses about the reasons for productivity weakness in Japan and why Japan's productivity level stalled out well below that of Germany and the United States. One compelling reason is the performance of small businesses. They make up a large part of the economy, more than two-thirds of employment and around a half of output, and their productivity is lower relative to large companies than is the case in other advanced economies (OECD, 2019b). Competition does not drive out the low productivity companies because of the system of loan guaranties and other regulatory protections. The OECD also argues that there is a problem in corporate governance in larger firms. Japanese firms have low returns on equity and corporate boards are made up of insiders.

Jorgenson and Nomura (2005) and Jorgenson and Motohashi (2005) suggest a strong link between productivity in Japan and investment in IT. They find an increase in IT investment in Japan after 1995 and a corresponding increase in productivity growth in 1995-2000. Arora, Drev, and Branstetter (2010) also link technology to Japanese economic performance but argue that Japan fell behind the United States in software innovation so that Japanese companies were not able to keep up with Silicon Valley over the period 1983-99. A related argument is that Japan has spent heavily on R&D, but the dollars have not generated good economic results (Bahar and Strauss, 2020).

A report for the think-tank RIETI, by Fukao (2010) notes that Japan's traditional productivity strength has been in manufacturing, but this is a declining part of the economy. Fukao further argues that Japanese companies have had difficulty taking advantage of IT investment. Morikawa (2019), also from RIETI, argues that service sector productivity in Japan is understated because of limited adjustment for the improvement in quality of service sector output.

Starting in the early 1990s, the McKinsey Global Institute conducted a series of cross-country comparative productivity studies. A main result for Japan was that the most productive Japanese manufacturing industries were ahead of the United States, notably in automobiles, machine tools and steel. Despite these successful industries, average labour productivity in Japan was found to be well below that in the United States with both service industries and protected domestic manufacturing industries at a productivity disadvantage.[24] The explanation for this pattern was that Japan's leading manufacturing industries were competing against the most productive global companies while the rest of the economy was protected against imports and was often highly regulated so that domestic competition was limited, allowing unproductive (often small) firms to survive. This view is consistent with sev-

24 The studies of productivity can all be found on the McKinsey Global Institute website at https://www.mckinsey.com/mgi/overview. The early studies were described in Baily (1993) and Baily and Gersbach (1995).

eral of the arguments given in the literature described above[25] and explains the overall productivity gap in terms of Japan as a dual economy, with part of the economy highly productive and part protected.

Jorgenson, Nomura and Samuels (2018) find that the highly productive industries in Japan pushed overall manufacturing productivity above the US level in the 1990s before converging back to the US level by 2017. Low productivity outside manufacturing, in their analysis, explains all of the current TFP gap to the United States.

How do the industry findings reported in the previous sections fit in with the hypotheses advanced in the literature? We will use the JNS results. Agriculture and wholesale and retail trade are industries where there are many small firms in Japan protected from competition, and their productivity is well below the US level in 1990, with no catchup occurring. Air, water, and rail transportation have productivity levels below the United States and there is either no catchup or, in the case of air transportation, a long way to go to catch up. Finance and insurance in Japan were also not catching up.

The mining industry in Japan is very small and so the comparison to the US industry may not be meaningful. The US computer and electronics industry shows up having labour productivity below Japan in 1990 but where productivity growth is faster and so convergence has taken place.

These industry results are broadly consistent with the literature suggesting that Japan's productivity gap to the United States is concentrated in services. However, the fact that many Japanese manufacturing industries show negative TFP growth from 1990 in the JNS analysis indicates that not all of the productivity problems are in services.[26] The labour productivity results by industry also confirm the view discussed in the literature, that weak capital investment has contributed to slow Japanese growth in recent years.

Conclusion

The German economy caught up to the US level of productivity in the 1990s and has since remained close behind. Their economy lacks the innovative IT sector of the United States but has other advantages, including strong worker training. German GDP per capita is well below the US level, but that is because German workers have many fewer annual hours of work, and more leisure.

The Japanese economy grew very strongly for many years and its leading industries set new productivity frontiers. In the 1990s that relative progress stalled out and GDP per hour worked fell further behind the levels achieved in both Germany and the United States. Increasing the level of competitive intensity and driving out low productivity small and large firms would

25 The OECD study argues that good corporate governance can improve productivity, but the McKinsey studies argue that product market competition is what is needed. Given the need for tangible and intangible investment, the OECD's concern about low profitability among large firms is well-taken.

26 A 2015 study by McKinsey argues that Japanese manufacturing has fallen behind the US in high-tech production. See Desvaux et al (2015).

help complete Japan's convergence to the productivity frontier. The Japanese manufacturing sector still has strong productivity performance, setting the frontier level of productivity in some industries, but its relative performance has declined. Negative TFP growth in several manufacturing industries is concerning and suggests deeper case study analyses are needed. The literature suggests Japan may have had difficulty with software development and the application of IT.

Recent productivity growth in the United States has been very slow indeed. There are promising technologies on the horizon but so far the gains are not being realized. The results in this article point to problem industries such as construction and utilities where productivity growth is very low or negative. While it is likely that productivity measurement needs to be improved, there are also underlying problems associated with regulation and a lack of effective competition.

Benchmarking industry growth rates and productivity levels across countries is an important way to determine where countries are falling behind and where productivity gains might be achieved. There are substantial differences in results depending on which set of PPPs are used, providing a cautionary note to these results.

The world is caught up in the Covid-19 crisis as this is written. Possibly this will accelerate trends that will enhance future productivity (in retail for example) but, more likely, a slow recovery will weaken investment and trend labour productivity for a time.

References

Andrews, Dan, Chiara Criscuolo and Peter N. Gal (2016) "The Best Versus the Rest: The Global Productivity Slowdown, Divergence Across Firms and the Role of Public Policy," OECD Productivity Working Paper, No. 5.

Askenazy, Philipp, Lutz Bellmann, Alex Bryson,and Eva Moreno Galbis els. (2016) *Productivity Puzzles Across Europe,* (Oxford: Oxford University Press).

Arora, Ashish, Lee G. Branstetter and Matej Drev (2010) "Going Soft: How the Rise of Software Based Innovation Led to the Decline of Japan's IT Industry and the Resurgence of Silicon Valley," NBER Working Paper, No. 16156.

Bahar, Dany and Sebastian Strauss (2020) "Innovation and the Transatlantic Productivity Slowdown: A Comparative Analysis of R&D Trends in Japan, Germany, and the United States," Global Economy & Development Working Paper, No. 135, Brookings Institution, https://www.brookings.edu/wp-content/uploads/2020/01/ProductivityComparisonsRD_final.pdf.

Baily, Martin Neil (1993) "Competition, Regulation and Efficiency in Service Industries," *Brookings Papers on Economic Activity: Microeconomics*, Vol. 2, pp. 71-159, https://www.brookings.edu/bpea-articles/competition-regulation-and-efficiency-in-service-industries/.

Baily, Martin Neil and Hans Gersbach (1995) "Efficiency in Manufacturing and the Need for Competition," *Brookings Papers on Economic Activity: Microeconomics,* pp. 307-358, https://www.brookings.edu/bpea-articles/efficiency-in-manufacturing-and-the-need-for-global-competition/.

Baily, Martin Neil and Nicholas Montalbano (2016) "Why is US Productivity Growth So Slow? Possible Explanations and Policy Responses," Brookings Institution, https://www.brookings.edu/research/why-is-us-productivity-growth-so-slow-possible-explanations-and-policy-responses/.

Baily, Martin Neil and Robert M. Solow (2001) "International Productivity Comparisons Built from the Firm Level," *Journal of Economic Perspectives*, Vol. 15, pp. 151-72.

Barro, Robert J. and Xavier I. Sala-i-Martin (1998) *Economic Growth,* (Cambridge, Mass: MIT Press).

Baumol, William J., Sue Anne Batey Blackman and Edward N. Wolf (1989) *Productivity and American Leadership: The Long View*, (Cambridge, Mass: MIT Press).

Blanchard, Olivier, Martin Baily, Hans Gersbach, Monika Schnitzer, Jean Tirole, Diana Farrell, Jűrgen Kluge and Eric Labaye (2002) "Reaching Higher Productivity Growth in France and Germany," McKinsey Global Institute, https://www.mckinsey.com/featured-insights/europe/reaching-higher-productivity-growth-in-france-and-germany.

Deloitte (2015) "European Energy Market Reform. Country Profile: Germany," https://www2.deloitte.com/content/dam/Deloitte/uk/Documents/energy-resources/deloitte-uk-market-reform-germany.pdf.

Desvaux, Georges, Jonathan Woetzel, Tasuku Kuwabara, Michael Chui, Asta Fjeldsted and Savador Guzman-Herrera (2015) "The Future of Japan: Reigniting Productivity and Growth," *McKinsey Global Institute.*

Dustmann, Christian, Bernd Fitzenbergerm Uta Schönberg and Alexandra Spitz-Oener (2014) "From Sick Man of Europe to Economic Superstar: Germany's Resurgent Economy," *Journal of Economic Perspectives,* Vol. 28, pp. 167-188.

Elstner, Steffen, Lars P. Feld and Christoph Schmidt (2017) "The Slowdown of German Productivity Growth," Working paper and PowerPoint presentation at the NERO meeting, http://www.oecd.org/economy/growth/OECD-NERO-june-2017-the-slowdown-of-German-productivity-growth.pdf.

Furman, Jason and Peter Orszag (2018) "Slower Productivity and Higher Inequality: Are They Related*?*", Peterson Institute for International Economics Working Paper Series, No. WP18-4.

Fukao, Kyoji (2010) "Service Sector Productivity in Japan: The Key to Future Economic Rrowth," RIETI Policy Discussion Paper, No. 10-P-007, https://www.rieti.go.jp/jp/publications/pdp/10p007.pdf.

Gutiérrez, Germán and Thomas Philippon (2017) "Declining Competition and Investment in the U.S," NBER Working Papers, No. 23583.

Gordon, Robert J. and Hassan Sayed (2019) "The Industry Anatomy of the Transatlantic Productivity Growth Slowdown: Europe Chasing the American Frontier," *International Productivity Monitor*, No. 37, Fall, pp. 3-38, http://www.csls.ca/ipm/37/Gordon.pdf.

Int-Team Consulting (2015) "The Textile and Clothing Industry in Germany," https://www.int-team.com/en/the-textile-and-clothing-industry-in-germany/.

Jorgenson, Dale W. and Kazu Motohashi (2015) "Information Technology and the Japanese Economy," NBER Working Paper, No. 11801.

Jorgenson, Dale W. and Koji Nomura (2005) "The Industry Origins of Japanese Economic Growth," NBER Working Paper, No. 11800, November.

Jorgenson, Dale W., Koji Nomura and Jon D. Samuels (2018) "Progress on Measuring the Industry Origins of the Japan-U.S. Productivity Gap," Harvard University Working Paper. https://scholar.harvard.edu/files/jorgenson/files/pl01b_jorgenson_nomura_samuels_-2018.pdf?m=1527941772.

Larson, Nicholas (2019) "Tough Times Persist for German Banking*,"* *International Banker*, https://internationalbanker.com/banking/tough-times-persist-for-german-banking/.

Lewis, Bill, Angelique Augereau, Mike Cho, Brad Johnson, Brent Neiman, Gabriela Olazabal and Matt Sandler *et al.* (2001) "US Productivity Growth, 1995-2000," *McKinsey Global Institute,* https://www.mckinsey.com/featured-insights/americas/us-productivity-growth-1995-2000.

Morikawa, Masayuki (2019) "Japan's Low Labor Productivity: The Gap With the US and Complex Causes," RIETI Papers, https://www.rieti.go.jp/jp/publications/pdp/10p007.pdf.

Nomura, Koji, Kozo Miyagawa and Jon D. Samuels (2018) "Benchmark 2011 Integrated Estimates of the Japan-U.S. Price Level Index for Industry Outputs," BEA Working Paper Series, No. 2018-15, https://www.bea.gov/system/files/papers/WP2018-15.pdf.

OECD (2016) "OECD Economic Surveys: Germany," https://www.oecd-ilibrary.org/economics/oecd-economic-surveys-germany-2016_eco_surveys-deu-2016-en.

OECD (2019) "OECD Compendium of Productivity Indicators 2019," Paris, https://doi.org/10.1787/b2774f97-en.

OECD (2019) "OECD Economic Surveys Japan," https://www.oecd.org/economy/surveys/Japan-2019-OECD-economic-survey-overview.pdf.

Romer, Paul M. (1986) "Increasing Returns and Long-Run Growth," *Journal of Political Economy*, Vol. 94, pp. 1002-1037.

Sharpe, Andrew and James Uguccioni (2017) "Decomposing the Productivity-Wage Nexus in Selected OECD Countries, 1986-2013," *International Productivity Monitor*, No. 32, Spring, pp. 25-43, http://www.csls.ca/ipm/32/Uguccioni_-Sharpe.pdf.

Schneider, Rolf (2013) "Low Productivity in Germany," Allianz Working Paper, No. 166.

Sinn, Hans-Werner (2006) "The Pathological Export Boom and the Bazaar Effect: How to Solve the German Puzzle," *The World Economy*, Vol. 29, No. 9, pp. 1157-1175.

Van Ark, Bart, Kirsten Jaeger, Vlad Manole and Andreas Metz (2009) "Productivity Performance and Progress, Germany in International Comparative Perspective," The Conference Board.

Van Ark Bart, Klass de Vries and Abdul Erumban (2019) "Productivity & Innovation Competencies in the Midst of the Digital Transformation Age: An EU-US Comparison," European Commission, https://ec.europa.eu/info/sites/info/files/economy-finance/dp119_en.pdf.