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LESSONS FROM PRODUCTIVITY RESEARCH

APPLYING THESE TO A STRATEGY FOR JAPAN

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ABSTRACT

This study presents selected lessons learned from productivity research. It examines the extent to which the key empirical questions about productivity have been answered. While the productivity growth residual (TFP) is still somewhat puzzling, soft innovations and new business models are seen as important contributors. Aggregate and industry growth data are reviewed and show how a few industries contribute a lot to overall growth; notable is the large contribution of high-tech manufacturing to U.S. TFP growth. Similar findings also hold for Japan. There is an extended summary of the lessons learned from cross-country comparisons of the levels of productivity in different industries using business economics information. High competitive intensity is positive for productivity, while regulations and trade restrictions are negative. The productivity lessons are applied to develop a strategy to improve productivity in Japan, stressing catch-up in protected industries, improving the education system, and the need to restore Japan's strength in high-tech.

ACKNOWLEDGEMENTS

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DISCLOSURES

I. Introduction

Productivity is a measure of the amount of output produced by a given level of inputs. The higher the level of productivity, the greater is the amount of goods and services that can be produced by an economy's workers, capital, and natural resources. Productivity growth over many decades has transformed America, Europe, and Japan into wealthy countries. The progress made since the start of the industrial revolution has been a miracle, allowing most people in these countries to live comfortably and have a range of economic opportunities. Rising productivity is not the only factor, but it is the most important factor, improving living standards and lifting people out of poverty.

The world economy is changing. Is productivity still as important? There is well-justified concern about global warming and the need to reduce emissions. Further, economy-wide productivity increases have not contributed proportionately to workers' wages, so that there is dissatisfaction about economic performance. This is a particular problem in the United States, where automation and trade have eliminated many of the jobs that used to provide middle class incomes. These same forces are also at work in other advanced economies, including Japan.

Despite these concerns, productivity remains just as important as ever. Meeting the challenge of climate change will mean heavy investments to switch over to non-polluting energy sources, replace the current stock of vehicles, and insulate buildings. Research and development funds are being used (correctly) to find ways to reduce emissions and many of the most talented people in the world are focused on climate change rather than on how to produce more output. Productivity growth has been slow in the advanced economies for several years, and the focus on climate change will provide a further drag on growth. That means it is even more important today to use resources as efficiently and productively as possible, subject to meeting climate goals. If robust productivity increases can be sustained, this can offset the sacrifices needed to achieve climate goals. Moreover, even though increases in productivity have not translated one-for-one into wage increases for all workers, it is still the case that faster productivity growth means faster wage growth on average, and it makes more resources available to help those with low incomes.

The first part of this study describes lessons learned from a career of studying productivity. I have had the opportunity to work with a range of talented people coming from different backgrounds and countries. Some of this work has been in the academic tradition, published in journals or by Brookings, and some has come from a series of productivity studies carried out by a leading business consulting company. These two approaches to research have complemented each other. Academic studies use data that can be replicated by others and that build on the work of the many giants of the field. The disadvantage of academic studies is that the authors generally lack detailed knowledge of how companies and industries operate. The consulting company studies, by contrast, included senior experts that had worked with firms and industries for many years. A disadvantage of the business research is that these studies cannot be replicated, except at great cost. To add to the economic expertise of the projects, a team of academic advisors was set up, with Nobel prize winner Robert M. Solow serving as the chair of the advisory committee for about a decade. I worked extensively on many of these studies.

The second part of this paper tries to apply the productivity lessons to Japan. The potential for productivity growth is particularly strong in Japan. The Japanese economy grew very rapidly in the 1960s. Japanese productivity growth was much faster than American productivity growth, as a skilled workforce was available, there was a high rate of investment, and a strong technology base. Japanese companies became world leaders in many technologies. Japan's productivity converged towards that of the United States and the leading European economies, such as Germany. However, the convergence process for Japan stopped short. The level of productivity in Japan remained below that of the leading economies. In the past few years, there has even been concern that Japan's economy is falling further behind. To reverse that relative decline, complete its economic catch-up, and converge fully to the productivity leaders, Japan will have to make hard choices. Traditional industry and employment patterns will have to be changed and not everyone in Japan will want to make those changes.

Two caveats are in order. First, this review of lessons learned is oriented to my own interests and the studies I have been involved with. There is a multitude of excellent research I will not cover here. Next, while I have been involved in productivity studies that have covered Japan, I am not an expert on the Japanese economy.

II. The questions productivity research has tried to answer

In 1957, Robert Solow found that about 80% of the growth in labor productivity historically came not from increases in capital per worker but from a residual factor that is now called total factor productivity (TFP) and is often associated with technical change or technological progress.[1] Much subsequent research on productivity attempted to better understand this surprising finding and figure out what was behind the large growth residual. Solow explored models where technology is embodied in capital goods—vintage capital models. These capture important insights into the economy, highlighting the productivity advantage of operating with the most advanced machinery. However, even in these models, it remains the case that the pace of technological progress is the most important driver of long run growth. If technological progress slows, investment runs into diminishing returns because new vintages of capital do not generate much productivity advantage over prior vintages, and investment becomes less profitable for businesses. Rapid technological change is the most important driver of strong investment.

Work by Dale Jorgenson of Harvard[2] and by Edward Denison of Brookings[3] differed in important ways and generated disagreement, but they shared the common goal of whittling down the TFP residual. They explored how the flow of capital services into production can differ from the stock of capital; how education and experience impact the productivity of the workforce; how R&D can contribute to growth; and the impact of economies of scale and regulation. Jorgenson expanded on the neoclassical growth model, and his productivity framework is now used worldwide.

While Jorgenson and Denison did succeed in whittling down the TFP residual somewhat, notably in identifying the contribution of human capital, there remains to this day a substantial puzzle to understand the nature and determinants of the TFP growth that has been the main source of the rapid labor productivity growth that characterized the U.S. and other advanced economies. Understanding the determinants of the growth in TFP and the reasons for TFP differences across countries remains an important question and puzzle.

A sharp slowdown in productivity growth occurred in 1973-4 that had substantial consequences for living standards and for economic policy. The slowdown in growth altered the TFP puzzle. The decline in productivity growth was associated with a large decline in TFP growth and so the unexplained productivity residual got much smaller. Capital accumulation also slowed around the same time, which can be linked to the drop in TFP growth because new investment was not as attractive in a slower growth economy when technology was not advancing as fast. Why did growth slow down sharply in the United States in the early 1970s, a slowdown that also took place in the other advanced economies?

An especially puzzling feature of the slowdown in productivity growth in the early 1970s is that the drop in the speed of growth was quite abrupt. If it had been the case that TFP growth had gradually shown signs of decline over an extended period of years, it would have been natural to attribute this slowdown to a gradual exhaustion of technological opportunities. If one envisages technological progress as a process of selecting new business models or new technologies from a pool of possibilities that nature has provided to us, then it is natural to think that it might become gradually harder and harder to find new ways to increase productivity. The relentless march of growth in the period from 1950 to 1970, in this analogy, resulted in diminishing returns to the process of drawing from the limited pool of new technologies and ideas. However, the nature of the slowdown that took place in the early 1970s does not fit very well with this view of a gradual decline. The sharp drop in growth is a puzzling and important feature of economic history. It probably is correct to say that the innovations that increase productivity have become harder to find, but the productivity slowdown remains a puzzle that is not fully understood.

Just as economists and policymakers were adjusting to an era of much slower growth, productivity growth in the United States abruptly picked up again for almost a decade before slowing once again, leading to another growth puzzle. Why did productivity growth revive in the United States 1995-2004 and then slow again after that?

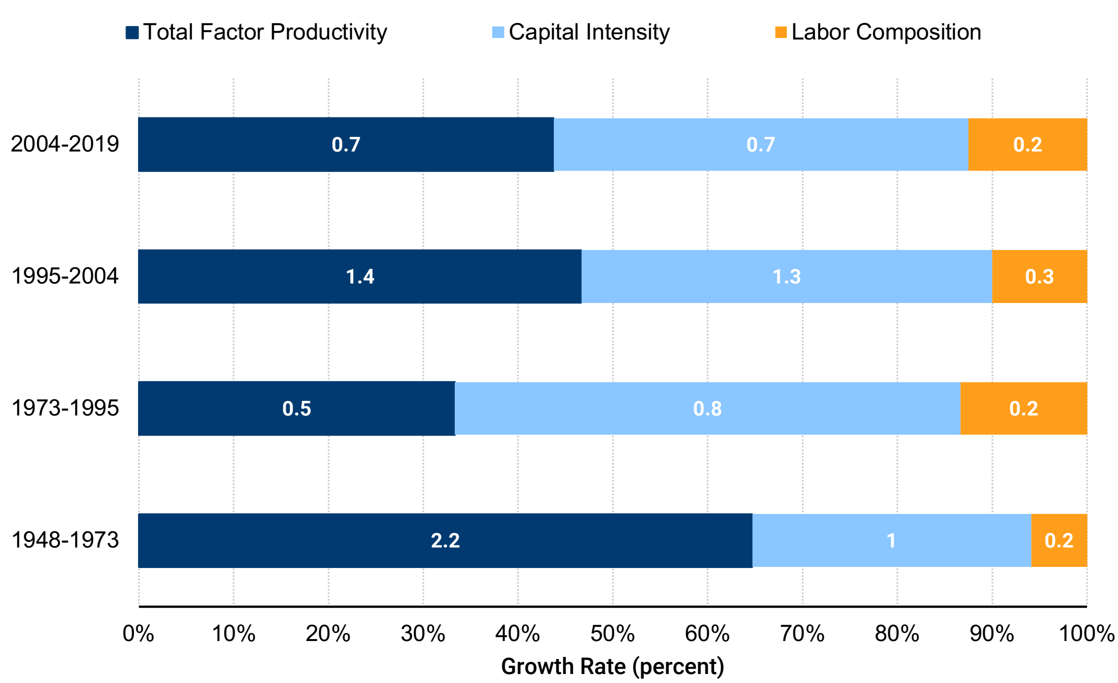
Figure 1 illustrates the different productivity periods since 1948, with estimates shown of the overall rate of labor productivity growth in the nonfarm business sector by period and the contributions to that growth coming from TFP growth, capital intensity, and labor composition (this last is the Bureau of Labor Statistics estimate of the contribution of human capital improvements).

The figure shows:

1. The slowdown in growth that occurred around 1973 was driven by a big drop in the TFP residual, from 2.2% a year to 0.5% a year.
2. The contribution of labor composition remains roughly constant over the entire period. It is a consistent contributor but not large and does not explain variations in period-to-period growth.
3. The contribution of capital to labor productivity growth tends to rise and fall in line with the rise and fall in TFP growth. However, the period 1995-2004 stands out as one with a very large capital contribution. This was when computer prices were falling rapidly and investment in computers was booming. The estimated increase in real (quality-adjusted) capital was very large.

FIGURE 1

Productivity Growth 1948-2019



Source: Federal Reserve Bank of San Francisco, 2022

Note: Total factor productivity, capital intensity, and labor composition for the year 2020 were -1.9%, 3.6%, and 0.9% respectively. These data are omitted from this graph because the pandemic made 2020 an outlier year

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The United States is far from the only economy that has experienced a slowdown in productivity growth. In the 1950s, the U.S. economy had a much higher level of productivity than Japan and Europe. Of course, many of these economies had suffered severe damage during the war. In the postwar period Europe and Japan grew more rapidly than did the United States, closing the productivity gap. Starting around the 1970s, however, the productivity slowdown affected almost all the advanced economies. Research from the Conference Board (which builds on OECD data) shows the pattern of the productivity slowdown. They use a technique called a Hodrick-Prescott filter, which takes the annual productivity data and smooths the year-by-year growth numbers to pick out the longer run trends. Figure 2 shows their results for Japan, the UK, the United States, and the Euro area. The figure finds that productivity growth in Japan, which was very rapid in 1970 (and before), has been slowing almost continuously since then. Productivity growth in the UK was stable for a period but has been slowing dramatically since the mid-1990s. Growth was slow in the U.S. in the 1970s and then had a period of faster growth before slowing again (consistent with the data shown in Figure 1). The euro area has also been slowing monotonically since the data for the combined area started. The line for the world economy is also shown and reveals that global growth has been slowing since the mid-2000s.

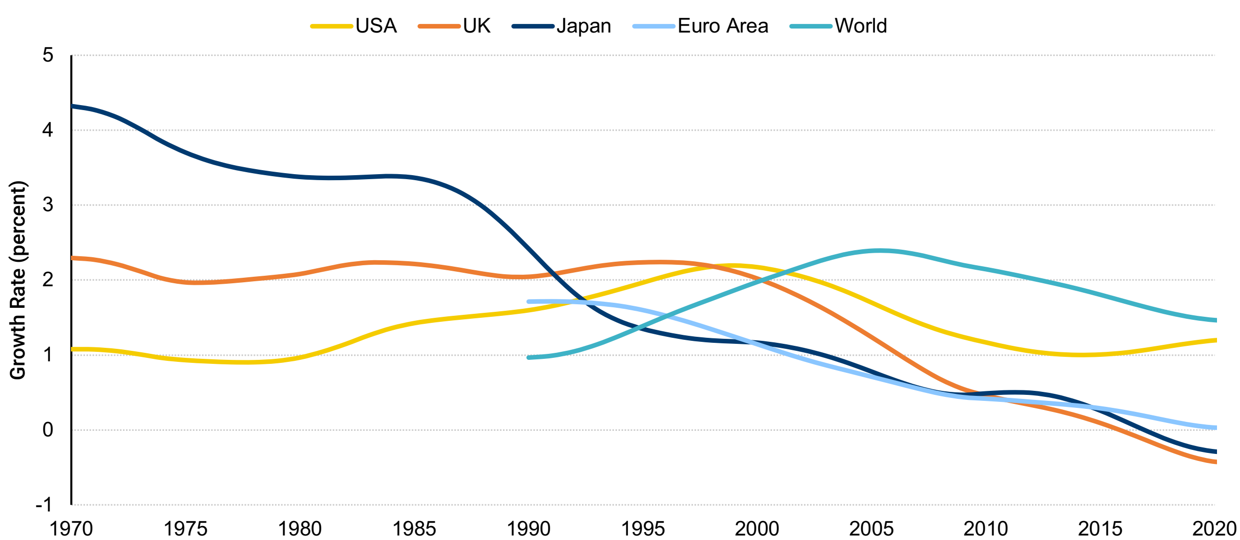
The results shown in Figure 2 must be interpreted cautiously. For example, the line for the United States shows productivity growth starting to improve by the early 1990s, a finding not at all visible in the year-by-year data. It happens because the Hodrick-Prescott filter program creates a smooth line and does not allow abrupt changes. Despite this reservation, the filtered data shown in Figure 2 provides a way of seeing patterns that would otherwise be obscured by numbers that change with each new observation. The pattern shown in Figure 2 illustrates an important point: The economies of Japan and Europe grew very rapidly in the postwar period, catching up the productivity level of the U.S. economy. However, this growth has slowed very markedly, even falling below the slow U.S. pace.

To provide additional insight into productivity patterns across countries, Figure 3 shows the levels of GDP per hour worked in four large economies: the United States, Japan, Great Britain, and Germany. By the end of the 1980s, the level of productivity in Germany had converged to that in the United States, and similar productivity convergence was true for several other European economies.[4] The period of fast growth in

FIGURE 2

Labor Productivity Growth Per Person Employed

Smoothed with Hodrick-Prescott filter



Source: The Conference Board Total Economic Database (2021)

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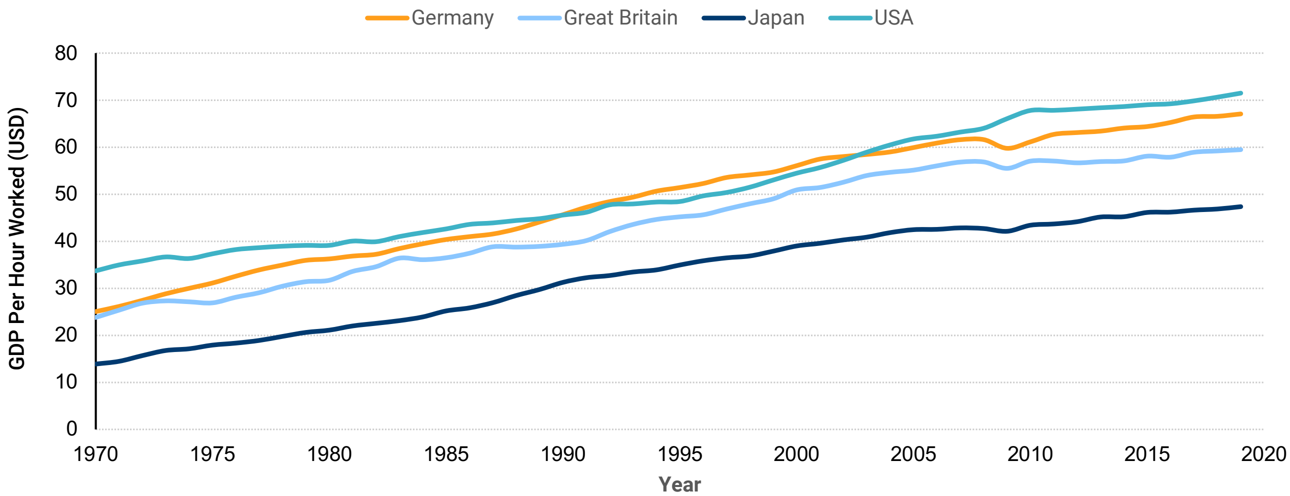
FIGURE 3

Productivity Levels, Selected Major Economies

GDP Per Hour Worked in Japan, Germany, Great Britain, and the United States, 1970-2019 (USD)



Source: OECD

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these converging economies had allowed them to catch up to the U.S. productivity level. However, that is not the case for Japan and Britain, and the gap is quite large for Japan. That points to a further question or puzzle. How are the levels of productivity among different countries related and why has convergence been incomplete in some countries?

The discussion so far has been based on economy-wide measures of productivity, and while the study of productivity at the aggregate level is valuable, we know that the economy is made up of thousands of companies that are grouped into many different industries. The answers to the four questions posed above will vary depending upon the nature of the firms and industries. The speed of productivity growth and its determinants are very different in the construction industry compared to the computer industry.

In the remainder of this document, the emphasis will be mostly on lessons learned about productivity based on different industries and, in a brief discussion, lessons learned from analysis using firm or establishment level data. Even if the ultimate goal is to understand aggregate productivity, it is important to look at the contributions of different industries. What do we learn about productivity from looking at different industries?

III. Industry contributions to overall productivity growth

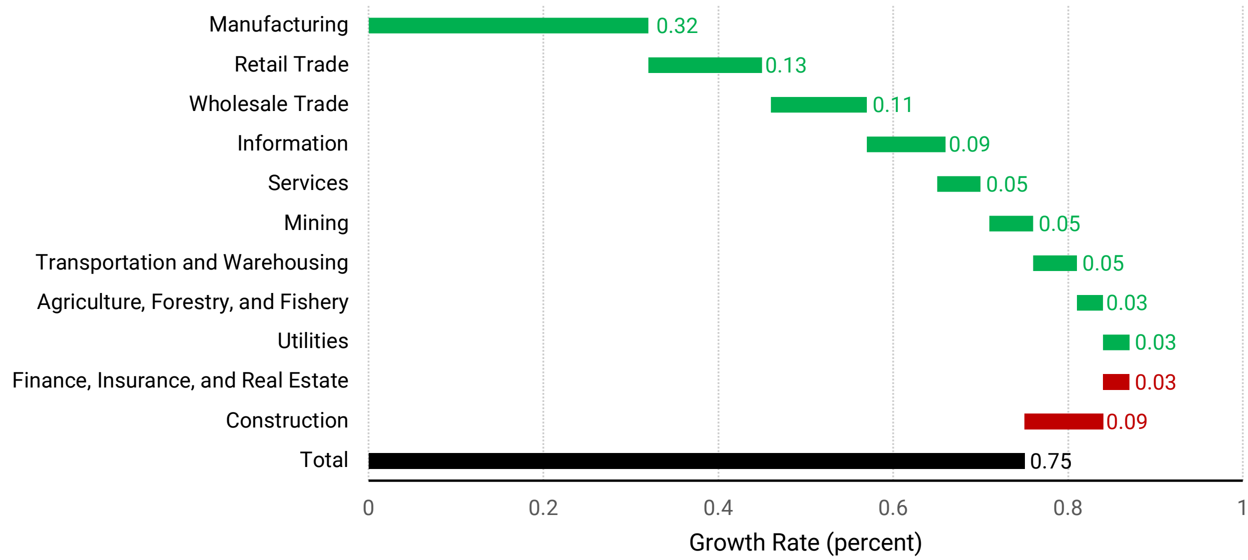
One way to determine the growth contribution of the individual sectors of the economy to overall growth is to make use of a result derived by using Domar aggregation.[5] Evsey Domar showed how to measure the contribution of TFP growth in each industry to the overall growth of the aggregate economy. For example, we can estimate the contribution of, say, manufacturing to TFP growth in the business segment of the economy, or the contribution of retail trade, and so on for each of the parts of business. The methodology is explained in the productivity handbook written by the OECD.[6]

The results of the decomposition of TFP growth by industry for the business sector of the U.S. economy are shown in Figure 4, from 1987-2019. The analysis starts in 1987 because prior to that year, U.S. industries were defined in different ways (computers and electronics was not a separate industry prior to

FIGURE 4

The Contributions of Industry Sectors to TFP Growth in the Business Economy in the United States

Aggregate U.S. TFP using Domar weights (1987-2019)



Source: US Bureau of Labor Statistics

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1987, for example). Results are available for 2020, but the COVID-19 pandemic has impacted these and made the findings difficult to interpret.

The immediate result revealed in Figure 4 is the enormous importance of a few industries to overall TFP growth in the United States. Manufacturing, retail and wholesale trade and information account for TFP growth equal to 85% of total TFP growth in the business economy. Services, mining, transportation, agriculture, and utilities all added positively to TFP growth while finance and construction both subtracted from growth. Perhaps the most striking result is the very large contribution from the manufacturing sector. It accounts for growth equal to 43% of the total. That is not to minimize the importance of the other industries, but to note the surprising role of manufacturing given its modest size in the U.S. economy. The contributions of retail and wholesale trade are also striking.

The contribution of manufacturing is so striking that it is worth asking whereabouts in manufacturing this growth has originated. To answer this question, Domar disaggregation can also be made for the constituent parts of manufacturing. Figure 5 shows the results of doing this.

The remarkable finding from this analysis is that over the period 1987-2019, almost all the TFP growth came from one industry, computer and electronic products.[7] As in Figure 4, there are positive contributions from other industries, but these are not very large and are offset by negative TFP changes elsewhere, particularly in chemical products. This figure tells us that while the high-tech sector in the United States is not very large in terms of employment and share of GDP, it is very important to productivity growth. Another important result obtained by looking at the manufacturing sub-industries is to see which of them experienced slow growth in recent years. The findings are shown in Table 1. The most striking finding in the table is the fact that the computer and electronic products industry appears to have experienced negative TFP change over the period since 2014. Thus, by far the largest driver of manufacturing productivity over the full period and one of the largest drivers of productivity growth in the full business economy experienced a productivity setback in the 5-year period prior to the start of the pandemic.

The fact that several industries and subindustries show periods of negative TFP growth is surprising. It is natural to think of TFP growth as representing technological progress or other business improvements. Why would companies or industries go backwards? There is no easy answer to this question, and it could reflect errors in the data. Perhaps capital or labor inputs have been miscalculated; it is important to always keep in mind that our knowledge of productivity is imperfect, and we should not over-interpret any finding. That said, the finding of negative TFP over a period of years may also reflect difficulties being faced by some or all the firms in an industry; perhaps their capital investment decisions were poorly made, and the capital is not being used in the way that was intended. Workers may produce output that is never sold. Negative TFP is a warning of possible problems within an industry that can be investigated further.

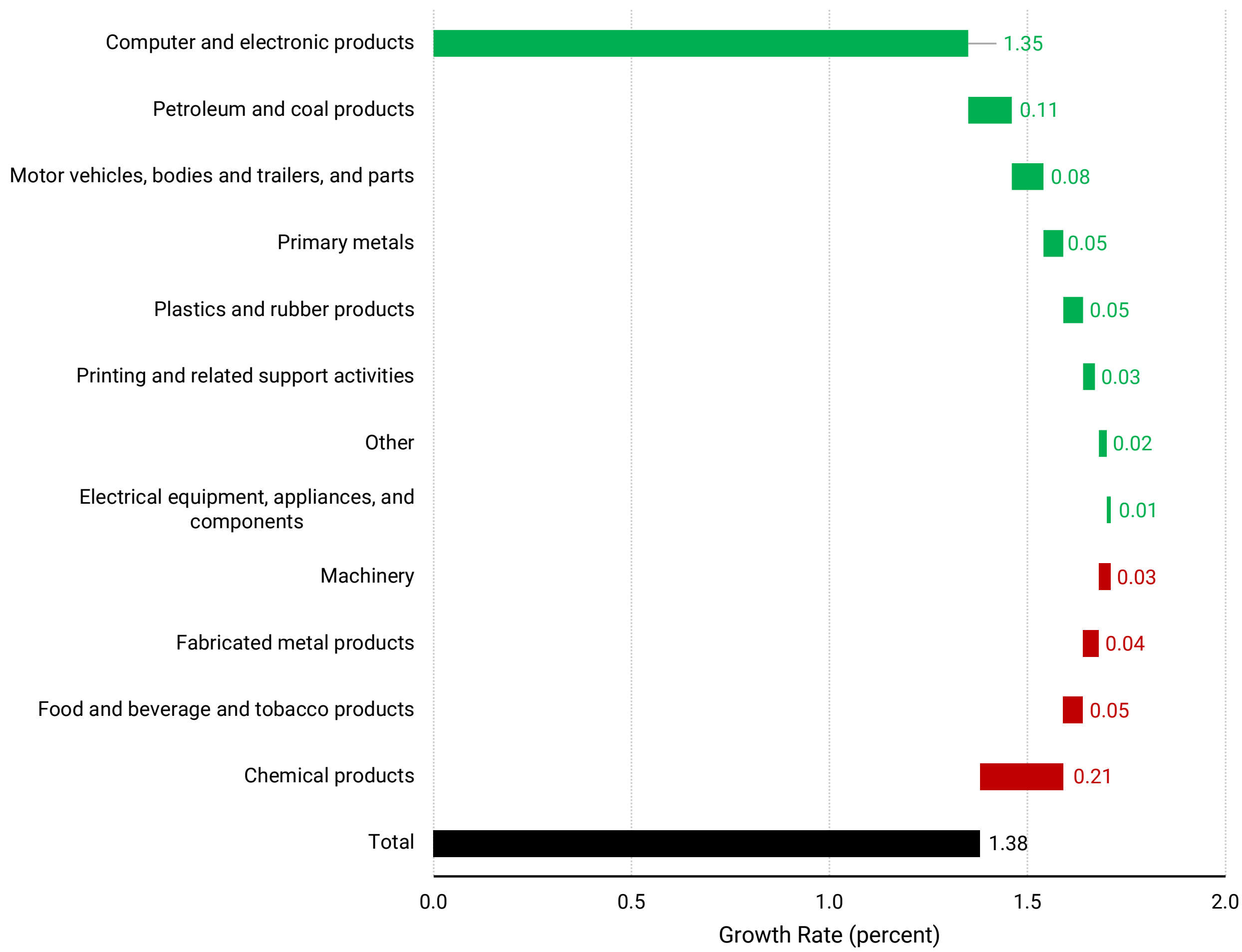
MEASURING THE CONTRIBUTION OF TECHNOLOGY SERVICES—THE FAANG COMPANIES AND OTHERS

Facebook, Apple, Amazon, Netflix and Google (FAANG, collectively) receive a great deal of attention both here in the United States and around the world. These companies have dominated their respective markets and generated a huge amount of wealth in the stock

FIGURE 5

The Contributions of Subindustries to TFP Growth in the Manufacturing Sector of the United States

Aggregate U.S. TFP using Domar weights (1987-2019): Manufacturing Subindustries



Source: US Bureau of Labor Statistics

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Table 1: TFP Growth by Manufacturing Subindustry, selected years

Subsector name	AVG 1987-2019	AVG 2014-2019
Computer and electronic products	1.352	-0.1283
Petroleum and coal products	0.1106	-0.02076
Motor vehicles, bodies and trailers, and parts	0.07872	0.005369
Miscellaneous manufacturing	0.05343	0.003931
Primary metals	0.05133	0.002389
Plastics and rubber products	0.04991	0.04953
Printing and related support activities	0.03279	-0.2391
Textile mills and textile product mills	0.02110	0.03736
Nonmetallic mineral products	0.01606	-0.01649
Electrical equipment, appliances, and components	0.009201	0.03532
Paper products	0.004430	0.03553
Furniture and related products	-0.003178	-0.02837
Apparel and leather and allied products	-0.005105	-0.09439
Wood products	-0.01570	0.2718
Machinery	-0.03092	0.03779
Fabricated metal products	-0.03923	-0.1487
Food and beverage and tobacco products	-0.04698	-0.08000
Other transportation equipment	-0.05003	0.02392
Chemical products	-0.2123	0.01078
TOTAL (manufacturing):	**1.377**	**-0.2424**

market.[8] What has been their contribution to productivity? Turns out that is a very hard question to answer. The ways in which productivity is measured or mis-measured has been an important area of research for Brookings, led most recently by Karen Dynan and Louise Sheiner (2018). This is not the place for a full-scale discussion of complex measurement issues, but I will briefly discuss the FAANG companies as a way of illustrating the measurement issues.

Amazon is part of the wholesale and retail trade industries.[9] Online shopping, where Amazon is the largest company, is very productive in that it can process orders from households and from businesses very quickly and efficiently. I have visited an Amazon facility and it is a marvel to see, although Amazon's employees face tough working conditions in achieving this efficiency.[10] Amazon's productivity contributes to wholesale and retail trade.

Amazon is also putting competitive pressure on traditional (bricks-and-mortar) retailers, forcing them to change and, potentially, become more productive. It is also contributing to the disruption of this industry, which has suffered because of COVID-19. There is excess capacity in retailing that is a drag on productivity. Further, the growth of online sales has led to a proliferation of deliveries. Trucks from Amazon, FedEx, and UPS drive around our cities, blocking traffic and crowding roads. The delivery of packages from online sales is counted in the transportation industry.

It is hard to assess the overall productivity impact of online sales. Thus far, Amazon has not brought about a big surge in productivity in wholesale and retail trade of the kind that occurred in the 1990s. This is partly because online sales are still only a fraction of total retail sales and probably because of the disruptions to traditional retail. It may be that wholesale and retail trade will see a new surge in the future.[11]

Apple carries out three main activities in the United States. It manages its global operations, does R&D to design products, and operates retail stores. The retail stores are very successful and are included in the retail sector, but they are not large enough to impact overall retail productivity. I was not able to get a definitive answer as to how Apple's other activities are counted.[12] The industry operations of a given company depend on how each of their establishments are counted. Apple does a lot of R&D that is geared to manufacturing activities, even though they do not actually manufacture products for sale in the United States. They do manufacture prototypes. These R&D and design operations create schematics for products that are then manufactured overseas. It is possible that some of Apple's activities are included in high-tech manufacturing in Figure 4 because of the design and R&D functions. They may also be counted in management services and even in wholesale trade as they organize global production. (Confidentiality restrictions mean that government agencies do not provide details about any specific company.)

To avoid paying U.S. taxes, Apple attributes much of its revenue to overseas locations rather than to the United States. This means that U.S. GDP and the level of U.S. productivity are being undercounted. This practice by Apple and other companies leads to an understatement of the level of U.S. GDP and an overstatement of the U.S. current account deficit. It also impacts U.S. tax revenues. It does not seem that this error is very significant for measuring recent productivity growth.[13]

Facebook and Google provide services to consumers and to businesses. However, their revenues are generated by advertising which is purchased by other businesses. Even though Facebook is used primarily by consumers, its revenue comes from other businesses, making it a producer of intermediate services. As a result, both companies show up in Figure 4 as part of business services (part of services in the figure).

Subscription television services, such as Netflix, are funded with fees paid by consumers and so they provide a final product (a service) that is purchased by consumers. Similarly, the companies that provide internet and cable TV to households also contribute to consumption through the subscription fees they charge. Netflix is counted as a consumer service.

There is a lively debate about whether technology companies, the FAANG companies and others, are being counted correctly in productivity.[14] Cell phones have transformed our ability to keep in touch with each other, find information, and take photographs. It is difficult to capture the value of these changes (leaving aside the shifting of profits overseas). Search companies, such as Google, provide an extraordinary service, but because search is funded by advertising, it is an intermediate good and its value to the economy may not be fully captured in our productivity measures.

A careful review of broad measurement issues by Byrne, Fernald and Reinsdorf (2016) concluded that measurement errors were not large enough to change important conclusions about U.S. productivity and the slowdown in growth. At the same time, some individual studies have found significant errors in the way specific digital goods or services are being measured. For example, a study by Byrne and Corrado (2020) suggests that the quantity of digital services provided to consumers (digital access services) are not being counted correctly. These are mobile phone signals, internet service, and cable TV and streaming services. Their prices have been falling rapidly over time, after adjusting for increases in speed and quality. The rate of price decline does not seem to have been accurately reflected in official data, which would lead to an undercounting of productivity in this sub-industry.

In this paper, I report data provided by government sources and the OECD for the United States, Japan, and other countries. These are the best data we have, and drawing on Byrne, Fernald, and Reinsdorf (2016), I believe the totality of the evidence suggests errors in the data are not too large and may be offsetting. The data are good enough. However, it is important to remember that economies change, and data is revised.

MEASURING THE CONTRIBUTION OF INDIVIDUAL INDUSTRIES IN JAPAN

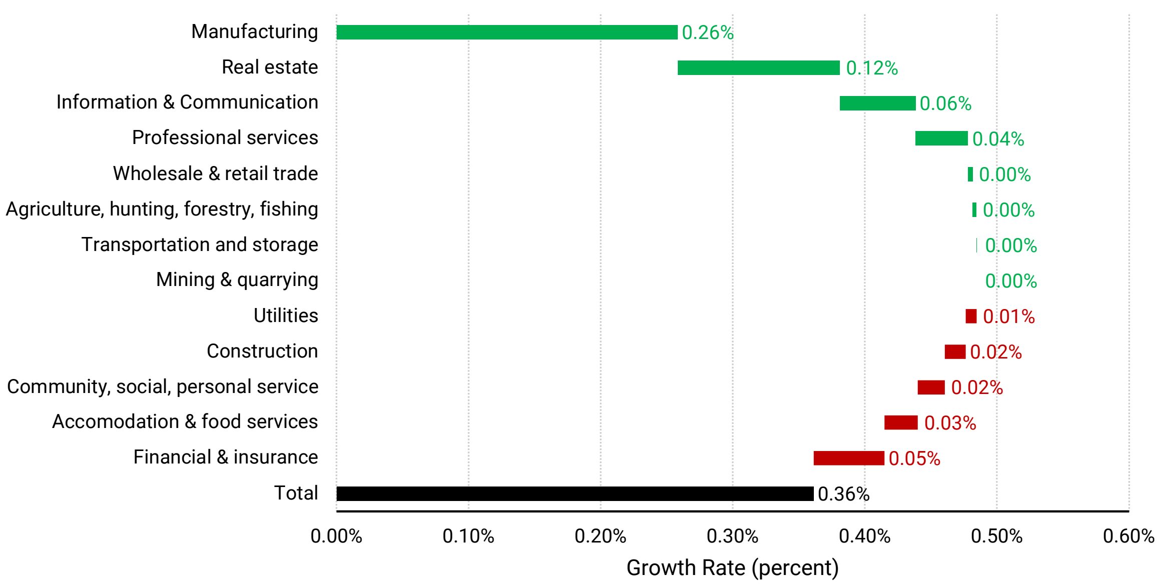
Using data from the OECD my research assistant calculated the contributions of individual industries in Japan. These are shown in Figure 6 below, with the contributions calculated using Domar weights, the same method as for the U.S. data given above. It is important to note however that there are some differences between Figure 6, for Japan, and Figure 4, for the United States. First, the time periods are different, which is because of data availability. The data that is consistent over time for Japan starts in 1996 and runs until 2019. That was a period of slow growth in Japan. Second, the data for Japan includes social services and nonprofits that are not included in the data from the United States. These will also tend to slow the measured growth of TFP in Japan compared to the United States.

Despite data differences, the results from Figure 6 giving the decomposition of Japanese growth are interesting. Manufacturing in Japan is the principal source of TFP growth for the economy. It represents 72% of the total TFP (although of course there are other contributing industries that are then offset by the negative TFP sectors). Surprisingly, real estate makes a substantial contribution to overall TFP growth. It would be worthwhile to investigate this sector to see how output and productivity are measured and how the growth is being generated. Information and communication make a contribution that surely reflects the advances in computer and related

FIGURE 6

The Contributions of Industry Sectors to TFP Growth in the Business Economy in Japan

Aggregate Japan TFP using Domar weights (1996-2019)



Source: OECD STAN Database

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technologies. Professional services are also significant contributors. Wholesale and retail trade makes a small positive contribution to Japanese TFP growth, but this is an area with much greater potential to contribute. There are five industries in Figure 6 that show negative effects on TFP growth. The negative impact of construction is less than that in the United States, but clearly the sector has problems in both countries. Some of this may be poor measurement, but this industry needs improvement in both countries. The results in Figures 6 can provide an initial guide in seeking the reasons why overall growth is slow in Japan.

My assistant also estimated a decomposition of growth within manufacturing, useful to know since it provides such an important contribution to overall growth. The results are shown in Figure 7.

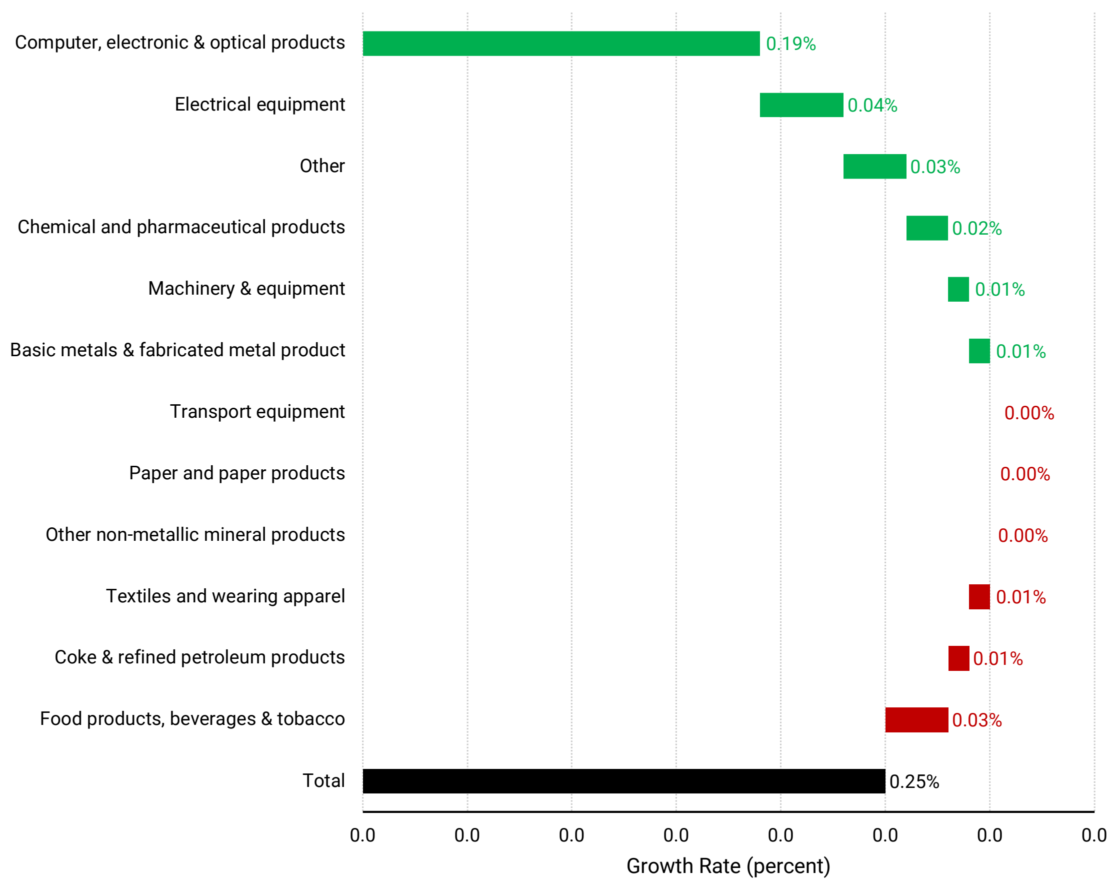
As is the case in the United States, the high-tech sector provides most of the growth over this period. Computers and electronics account for 76% of the total, while this industry plus electrical equipment account for 92%. Three industries make measurable negative contributions to TFP growth, notably food processing, which subtracts an amount equal to 12% of the total positive TFP growth in manufacturing.

I turn now to a review of the findings from a series of studies of productivity by industry across countries. This work, carried out mostly in the 1990s and early 2000s, looked at the levels of productivity, mostly labor productivity, and explored why, for example, the auto

FIGURE 7

The Contributions of Subindustries to TFP Growth in the Manufacturing Sector of Japan

Aggregate Japan TFP using Domar weights (1996-2019): Manufacturing Subindustries



Source: OECD STAN Database

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industry in Japan had higher productivity than that in the United States or why service industries in the United States often had higher productivity levels than in other countries. This review will be designed to elicit specific lessons from these studies to understand the role of capital, technology, and organization. And the studies also asked how the economic environment influenced the choices companies made about how to operate and how intensively they pursue the goal of improving productivity.

IV. Learning from business economics research

In the early 1990s a nonprofit group within a leading consulting company was created to research important economic issues that could be informed by the knowledge provided by experienced business consultants working with leading economists.[15] It was decided that a central focus of the research would be to compare productivity across countries by industry and try to understand why differences occurred. This is a natural topic because of the knowledge consultants have of how firms and industries operate in many countries. Robert M. Solow was brought in to chair the academic advisory committees formed for each study and, for the first study, he asked Francis Bator[16] and me to make up the other members of the committee. Over time a range of different economists joined the projects with an emphasis on adding economists from the countries being studied. Leading economists and Nobel prizewinners such as Olivier Blanchard, Barry Bosworth, Mike Spence, and Chris Pissarides have been involved in the work. The results of the studies were always published in extended reports. Several of the studies were presented in articles in the Brookings Papers. William Lewis who led the teams in the 1990s wrote *The Power of Productivity* about this work, and Solow and I wrote a paper in the *Journal of Economic Perspectives* about it (see footnote 16 and the bibliography).

This section will describe some of the learnings from this work in some detail but first a summary paragraph highlighting the most important findings. First, the studies found that there were quite large differences in the levels of productivity across countries in the same industry. At the time of the research, there had not been a full productivity convergence among advanced economies *at the industry level*. Second, a high level of competitive intensity forces firms to achieve the level of productivity of the best performers in their industry, or close to it. And if companies compete against the most productive companies world-wide, they have to match that best-practice productivity level. Third, certain types of regulation, as well as trade and investment restrictions, will prevent the industry in a country from achieving best practice productivity. Fourth, operating at large scale often provided a productivity advantage. And fifth, promoting high productivity is not a simple thing. The drivers of productivity or the barriers to productivity varied by industry and country. There were occasional surprising exceptions to the general rules just described.

Most of the productivity studies I discuss here were carried out in the 1990s through the early 2000s, so the results are out of date. This can be very important when looking at specific industries/countries where the competitive dynamics may have changed over time and regulation and trade rules may be different than those that applied when the studies were carried out. The lessons for productivity are not out of date, I believe, and will give insight into important determinants of productivity that still apply today.

THE ROLE OF CAPITAL

Capital goods are obviously essential to production in almost all economic activity. A modern factory is full of equipment. Offices are housed in expensive buildings, with furniture, fixtures, and office machinery, computers for all employees, mainframe computers for accounting, billing, and other tasks as well as copiers and telecommunications equipment. All high-income economies are built on a capitalist model, even those that have state ownership of some companies. It was natural for economic models of growth to single out capital as the key factor of production, and it was a shock when its importance to productivity growth turned out to be, while not trivial, smaller than expected.

Given that history, it probably should not have come as a surprise when cross-country productivity comparisons did not find differences in capital intensity *across the advanced economies* to be a substantial cause of productivity differences. Capital might have been expected to show up as an important cause of productivity differences in manufacturing industries, but instead it was found that factories were equipped similarly across these economies. The companies that make capital goods sell them around the world, so factories in different locations generally have comparable equipment and look very much the same.

As noted earlier, there is a lot of complexity involved in productivity, and so there are qualifications to the above discussion. Capital goods are expensive and last a long time, and they embody the technology available when they were constructed. There were examples where a recently built factory is more productive than older factories. For example, Korea set up Pohang Steel Company that began operations in 1968 with a state-of-the-art factory supplied from Germany that was for some years one of the most productive integrated steel mills in the world.[17] A more recent example of the value of advanced machinery, as described in press reports, is that Tesla uses very advanced capital goods to achieve high productivity.[18]

The finding about the role of capital intensity has also been questioned in the UK where capital intensity is substantially lower than in Germany. On the face of it, UK companies should have good access to capital through the strong financial sector in the UK, but it is argued that UK companies demand very high rates of return on investment and seek those returns through foreign investment rather than improving productivity domestically.[19]

Despite such qualifications, the productivity studies found in most cases that the way factories or offices or retail facilities were operated were much more important to productivity than differences in the capital stock. And there were even examples where high levels of investment had contributed almost nothing to productivity. The study of Korea, for example, found that government development policies had, in some industries, encouraged overinvestment where machinery was underutilized. Another example came from Germany where union restrictions on shiftwork meant that companies had to invest in extra capital to produce a given level of output and capital utilization was low compared to the United States.

THE ROLE OF HUMAN CAPITAL

The level of education of production and non-supervisory workers was not found to be an important determinant of productivity. A striking example came from a comparison of residential construction in Brazil and the United States. Productivity was very low in Brazil, only about one-fifth of the U.S. level. The conventional wisdom in Brazil was that this low productivity was the result of the low educational level of the construction workers. Most had received only a few years of education, and many were unable to read and write. However, a comparison of residential construction sites in Brazil and in the United States found that the U.S. construction workers were immigrants (mostly from Mexico) who had also only completed a few years of education, and most were unable to read and write. Instead, the productivity difference arose from two main reasons. First, most U.S. residential construction is carried out in sites where a large area is cleared and then multiple copies of pretty much the same house is built. This allows economies of scale. Second, a U.S. construction site is carefully orchestrated by site managers. Special trade workers, such as plumbers, carpenters and electricians are brought to the site only when required. These workers move from site to site as needed. Utilization of labor is much better in residential construction in the United States.

The retail industry provided another example where education was not seen as important for non-supervisory workers. Retail companies such as Wal-Mart do not require much education for their workforce. Worker productivity is achieved through training, the design of work procedures, and through performance incentives. Big-box retailers like Wal-Mart typically have very high levels of staff turnover and build productivity into the business system rather than relying on worker skill.[20] There is a contrast with some German retailers in the 1990s that had apprenticeships where cashiers were required to memorize all the products the store so that they could cash out customers quickly without checking price labels. The arrival of universal product codes and scanners rendered that labor skill unnecessary. Indeed scanners were much more productive since they can be used for inventory management.

As with the construction example, the managers and computer systems engineers at productive retailers are very skilled and designed systems to coordinate wholesale and retail functions and ensure deliveries were on time and sent to the right store.

A similar story applies to the fast-food industry, where the staff in the outlets often do not have much education. They receive basic training to perform the tasks they are assigned, and the layout of the premises and the design of the equipment allows high productivity. The cash registers make change and do not require a knowledge of English. The cooking is monitored by the fryers and ovens. This describes low-cost outlets like McDonalds, but even higher-priced restaurants use factory-prepared components that are cooked and assembled using carefully worked out procedures, rather than skilled chefs.

THE IMPORTANCE OF HUMAN CAPITAL: CAN THESE FINDINGS BE CORRECT?

There is a huge economics literature that makes the case for the importance of education to wages and to the economy. Alan Keueger, for example, working with Joshua Angrist, found that the accident of birth date impacted how long some students stay in school and that even staying a few extra months in school added to lifetime earnings.[21] He and Orley Ashenfelter used identical twins to demonstrate the contribution of education to earnings.[22] Claudia Goldin and Lawrence F. Katz wrote *The Race Between Education and Technology* in 2008, that argued that the demand for and supply of human capital have shaped the distribution of earnings in the United States. Baily, Bosworth, and Kennedy (2021) argue that differences in human capital returns in Japan relative to Germany and the United States play a role in productivity differences.

It is hard fully to resolve the difference in conclusions between the productivity studies from the business consultants and the academic findings on the value of education, but the following ideas may help.

Skilled managers, scientists, engineers, and professionals are important in creating productive companies and in developing new technologies. The strong universities in the United States have contributed to the supply of this segment of the workforce and encouraged creativity, innovation, and entrepreneurship. Nothing in the productivity studies contradicts this.

There are different ways of running productive companies, described in the labor economics literature as the high road and the low road.[23] With exceptions, U.S. companies take the low road, building productivity into their business systems, setting low wages for production and non-supervisory workers, and accepting high rates of turnover. Again, with exceptions, German companies take the high road, relying on well-trained workforces and creating high-quality outputs. German manufacturing is much bigger than the sector in the United States, adjusted for the relative sizes of the two labor forces. It pays good wages and runs a huge trade surplus supplying specialized and high- quality products around the world. The two countries end up with similar productivity levels.

The economy is changing. In the past, a high school diploma or a degree from a community college was enough to allow Americans to get a good job and earn a living wage, often in a unionized company. Even if companies did not especially value the specific knowledge acquired in high school beyond basic skills, they did value the signal provided by a diploma which demonstrated the willingness to work hard and to accept training. The widespread dissatisfaction with the available pool of jobs, and the social antagonisms that have been the result, demonstrate that America's low road approach is creating problems. The inability of many students to handle student loans suggests that spending extra time in school does not raise wages much for all students.

THE ROLE OF TECHNOLOGY

There is a great emphasis on technology, and advanced technology particularly, as a source of productivity growth. This goes back to the original growth models where the TFP residual was seen as coming from technological change. In the cross-country comparison studies, however, the importance of high-tech was questioned. The high-tech sector is small in all countries, even in the United States or Japan. Its share of employment and GDP are both small. Nevertheless, the products and services of this sector could be important in influencing productivity elsewhere in the economy. The comparative studies found, however, that proprietary technology was not a major source of productivity level differences across economies. The reason for this is that most technology products are available on global markets. Machinery and equipment, including computers, are sold around the world and so is software. We gave the example earlier of the Korean steel industry, where a huge integrated steel mill was built using the most advanced available German capital goods.

Soft Technology: Product Design and Organization of Functions and Tasks. Hard technology can generally be purchased globally, but "soft" or organizational technology can be much harder to transfer internationally and can depend on a company's specific skills and culture.

One of the best examples of this came from the automobile industry. The Japanese auto industry in the 1990s was substantially more productive than the industry in the United States or in Germany. Toyota was acknowledged to be the global productivity leader, although other Japanese companies had adopted many of the practices used by Toyota. The Toyota production system had been developing gradually for many years and it involved three main elements. First, incremental improvements were constantly made on the production line to reduce wasted time and materials and to make sure parts were available at the right time and in the right location. This efficiency was achieved by checking and redesigning the process and by using suggestions made by workers on the line. Second, the cars were designed to make them easy to assemble. Parts were simplified and designers looked for ways to reduce the number of parts needed. Parts could be fitted together easily and secured in place with a minimum of time. One consequence of these design improvements was that the cars became much more reliable. Japanese cars sold in the United States could be priced at a premium because of the reputation they developed for reliability.

The third important element of the Toyota production system was the way in which the company worked with their suppliers as part of a keiretsu. The suppliers formed a close relationship with Toyota, a pattern that was replicated with other Japanese original equipment manufacturers (OEMs). Engineers from the OEM would visit the supplier factories and make suggestions for ways to cut cost and improve designs or quality. The OEMs would maintain their relationships with their suppliers over long periods, although it was made clear that suppliers were expected to make continuous improvements. The American companies, instead, developed arms-length relationships with suppliers, generally requiring that more than one company supply components. There would then be pressure placed on the suppliers to reduce component prices. This would squeeze profitability and make it difficult for the suppliers to invest in new equipment or to do R&D to improve quality or to improve designs. Over time, many parts suppliers moved operations to Mexico or other low-cost supply locations.

It proved very difficult for the American companies to adopt the Toyota production system. This is surprising because it did not involve proprietary technology; indeed, Toyota formed a joint venture with General Motors in the 1980s (NUMMI) in a factory in Fremont, California. GM executives visited this factory but did not try to transfer the technology to their U.S. operations for many years. Ford learned about the Japanese production technology through its partnership with Mazda and did transfer some aspects of the system, notably in the design and production of the successful Ford Taurus.

WHAT FACTORS IN THE ECONOMIC ENVIRONMENT DETERMINED PRODUCTIVITY DIFFERENCES?

Several factors have been listed above as not being central to productivity differences and one factor was listed as significant and more important than is often realized—soft technology. This subsection takes the story further by asking what factors in the economic environment contributed to companies and industries achieving global best practice productivity. The answers are: first, competitive intensity; second regulation; and third, scale.

In the comparisons of manufacturing industries across advanced economies, one of the industries was identified as the global leader in productivity. For example, in automobiles the Japanese industry was the leader and the industries in other countries were considered follower industries. The leader industry was then assigned a productivity of 100 and the relative labor productivity of follower industries was measured relative to the leader. Then a second calculation was made as to how much the industry a country was "exposed" to the productivity leader. This calculation was based on three elements. First, does the industry compete in its home market against companies originating in the country of the productivity leader? For example, when Japanese companies built factories in the United States, this forced the U.S. auto industry to compete directly against Toyota, Nissan, and other companies. Second, does a given industry compete against the leader through trade in third markets. For example, how much does, say, the German industry compete against the Japanese industry in its export sales? And third, does an industry sell into the market of the productivity leader. These three factors were then weighted into an index, the globalization index, measuring the exposure of each of the follower industries to the productivity leader.[24]

It was then found that exposure to direct competition with the global productivity leader forced an industry to improve its own productivity in response to the competitive pressure. Alternatively, those industries that were protected against competition from the global productivity leader tended to have lower productivity.

A figure showing the positive correlation between an industry's productivity relative to the global leader and the index of its exposure to competition is shown in Figure 7 of Baily and Gersbach (1995). The resulting correlation is not perfect, but it is strong. It shows that when a manufacturing industry competes against the best global companies in their industry, this forces them to improve their own productivity to try and keep pace. The correlation confirmed the view of the business industry experts, and applies also, they judged, to service industries. Industries that are protected from competing against the best global companies in their industry will often form comfortable oligopolies that do not strive to be more efficient but are content to make adequate profits and avoid risky changes or expensive investments in new methods or products.

The measured level of productivity in an industry depends on both the level of output and on the level of inputs. Improving productivity will often mean finding ways to produce the same output with fewer inputs. But raising output without a comparable increase in inputs will also increase productivity. For example, products that are well-designed and reliable can be sold at a higher price, boosting productivity.[25] Alternatively, a company that understands what consumers are looking for and can follow shifting tastes can avoid excess capacity and use its workers and equipment more effectively.

The effect of *regulation* was found to be strongly linked to the competitive intensity just described. The regulations that had a negative impact on productivity were those that limited competition. These limits could come from international trade restrictions (trade barriers of all kinds). Trade restrictions apply primarily to manufactured goods. Regulations can be used to restrict land use, making it impossible for a best-practice company to come into a market or compete. Restrictions on direct foreign investment make it hard or impossible for a leading global company to enter and operate in a given market. For example, Sweden had restrictions that prevented foreign banks from entering their market, with the result that Swedish banks had inefficiencies in their operations. With their entry into the EU, Sweden opened its market and allowed foreign banks to enter and force the domestic banks to become more efficient.

Sometimes there were regulations that were idiosyncratic, affecting one specific industry. For example, Germany is very proud of its beer and had complex regulations arounds its production. So-called purity laws restricted how production is carried out and in some cantons the beer sold in a canton had to be manufactured within the canton. German beer is of high quality, but the proliferation of small sub-scale breweries resulted in low productivity. It was judged that the beer made in Germany could be made with optimal-scale plants at higher productivity without sacrificing quality if regulations were eased.[26] The production of sake in Japan also faces similar restrictions.

Labor regulations can also impact productivity in two main ways. First, union rules may restrict the ways in which companies can improve their production processes. For example, I noted earlier that General Motors was able to see how a Toyota plant operated through its joint venture in California, but they did not bring these ideas back to their own plants in Michigan, at least not for many years. One reason was a belief that they did not need to change, but another reason was that the union did not want to operate using the Toyota production process, believing that the Toyota approach would undermine the worker protections they had in place. In addition, union pressure can lead to trade restrictions or other regulations that protect jobs but hurt productivity. In Japan, employers today express concern that restrictions on reducing employment have adversely impacted productivity.

In Europe, unions in many industries resisted change on the grounds that jobs would be lost. EU rules were intended to force member countries to open their markets, but not all countries followed these rules to the same degree. Countries such as Italy and Portugal had very entrenched companies and unions that resisted change. By contrast, Sweden was able to open its economy to competition, and it achieved very strong productivity growth in the 1990s.

I take seriously the concerns of labor unions to protect their workers. Automation and international trade have eliminated many well-paid jobs and caused social discontent. Ideally, countries should retrain workers that are made redundant and protect them from income losses, but not all countries do this well. Sweden is a country that combines strong productivity with protection of workers. German manufacturing unions protect their workers but also recognize that companies must remain internationally competitive. German training programs allow workers to move to different jobs when necessary.

The example of the beer industry leads into a broader discussion of scale. There are scale economies in production in many industries, in fact pretty much all industries up to a certain production level. Scale economies were not found to account for big productivity differences across advanced economies for the most part. The German beer example is an exception rather than the rule. Mostly companies operate plants at sufficient scale that allows them to be productive. Still, there are some advantages to scale and access to a large market. Large companies can spread fixed costs over high production levels, giving them a better chance to spend on R&D or on other forms of product or process development. Large companies can experiment and try new products or new process designs and cover the cost if these turn out to be failures. Of course, size is no guaranty of success. General Motors was the largest auto company in the world but ended up in bankruptcy. IBM dominated mainframe computing in the past but is a much smaller company today.

The one consistent effect of scale found was that richer countries produce and sell more goods and services that are higher value-added and have higher measured productivity. Luxury cars and luxury hotels can be sold with higher margins than budget cars and motels. The United States, which has both a large market and many rich consumers, achieves a modest productivity advantage from these characteristics. The EU, of course, has now created a market that matches the U.S. market in size and China's market has grown to match these in size, although China still has a lower GDP per capita than the advanced economies.

WHAT DETERMINES THE PRODUCTIVITY LEADER?

The simple answer to this question is that we do not know exactly why innovation occurs in one location rather than another. There is serendipity involved in innovation; chance plays an important role. That said, there are economic conditions that favor innovation, and there are policies that can make innovation more likely. Factors that support innovation are as follows:

- A high level of competitive intensity, as we have seen, encourages companies to adopt available best practices—to catch up to the productivity leaders—but it also encourages productivity leaders to innovate to maintain an advantage over their competitors. That advantage may be only temporary, but leading companies innovate continuously to stay ahead.
- Although competition favors innovation, an industry that is fragmented, consisting of large numbers of small companies, may not be innovative, at least not without help. Agriculture provides an example. In the nineteenth and early twentieth centuries, this industry in America consisted of thousands of small farms. Some farmers were innovative and found new ways to increase their production, but for the most part farmers were too busy keeping their farms operating to spend time and resources on innovation. In response, government stepped in and created research departments in universities, research laboratories, and agricultural extension programs to create and disseminate innovation to this sector. Agriculture has achieved very strong productivity growth in the United States.
- The previous example illustrates one way in which government can play a positive role in innovation, and there are other examples. Government can encourage and support research efforts whose results are then available to all companies. The German government has provided consistent financial support for the auto industry in that country, with research facilities and training. Government can also give research grants to the private sector to encourage new industries. Such grants were important in the early days of Silicon Valley, where Stanford University formed a research park to take advantage of the emerging opportunities in semiconductors. Government support has also been vital in the emergence of other research hubs, such as Research Triangle in North Carolina and the companies around Cambridge University in the UK. The Defense Advanced Research Projects Agency in the United States has famously supported innovations. Another important way in which government has supported innovation historically is as a customer. In the early days of integrated circuits, the U.S. Defense Department was the largest customer.
- Another historically important role for government is through the patent system. Innovating companies can patent their inventions and create a monopoly for themselves for several years. Patents are a way of providing incentives for companies to spend on R&D and product or process development. Current thinking is that the patent system has both negative and positive impacts on innovation. The industry that has benefitted most from the patent system is the pharmaceutical industry, where new drugs are patented, and the developing company can earn huge returns for their successful products. The disadvantage is that patients or insurance companies then pay high prices for medications. European countries mostly limit the ability of drug companies to charge high prices. Patents can also discourage innovation. For example, an electronics company that holds a key patent can make it costly or impossible for other companies in the industry to innovate in the same technological area. In the early days of Silicon Valley there were cross-licensing agreements that allowed different companies to use each other's patents, but today there are lengthy, expensive court battles to enforce patents, with potentially negative effects on innovation. It is important that the patent and legal system in a country sets reasonable patent fees to encourage competition and innovation, not discourage it.
- Creating an industry with productivity and innovation leadership depends on the availability of talented people with the right knowledge and skills. Generally, this is thought of in terms of people with scientific and technical knowledge, and indeed these skills are important, but innovative business ideas are just as important. Entrepreneurs who develop new business models are not necessarily technology experts, rather they are people with the vision to see opportunity and the willingness to take risk. An environment where failure is allowed and where venture funds are available is important.

V. Lessons from Studies of Establishment Data

This section is a short description of some of the findings that have been obtained using government data collected from individual establishments. In the United States the Census Bureau collects survey data on individual establishments. These differ from data on individual firms because large firms typically operate many different establishments, often in different industries. The Census Bureau's data allows for the study of specific industries, consisting of all the establishments producing roughly the same type of product—automobile assembly plants, for example, or auto parts producers. The best data is available for manufacturing establishments, but there is some research that has extended to service industries as well. In an anonymized form, the data is made available to researchers. John Haltiwanger of the University of Maryland has been the economist that has helped develop the database for others to use and has published much research of his own. I participated in this research effort in the 1990s.

Although this section will not do justice to the extensive literature that has emerged using the establishment data, which now extends to work in other countries, (in fact, Canada pioneered the development of such databases) here are a few important findings.

- Productivity growth in an industry comes from improvements within existing establishments, but also comes from the relative expansion of the more productive plants and the relative contraction of the less productive plants.
- Plants that close (exit the industry) are lower productivity than the industry average. New entrants to the industry also tend to be lower productivity than the average, but those that remain in operation increase their productivity more than the average and move up in relative productivity.
- The distribution of productivity levels within industries has become wider. That is to say, the gap between the low productivity establishments and the high productivity establishments has increased.

The first two points illustrate the importance of the dynamics among plants to overall productivity growth. These findings are consistent with the results from the business studies. A competitive industry will have establishments that are more successful and some that are less successful, and if the more productive ones expand their share of the market, that is a boost to overall productivity. The establishments that are failing will eventually go out of business. Similarly, a dynamic industry will see new establishments entering the industry, starting with low productivity, but then either growing and moving up the distribution, or else dropping out.

These first two results come mostly from studies in the 1990s or early 2000s. The studies showing the increasing gap between low- and high-productivity plants come from more recent research. This is a sign that the dynamic movement of establishments within an industry that contributed to productivity in the past has slowed down. Low-productivity plants are remaining in operation even though they are not catching up to the best plants in their industry. That result is consistent with fact that productivity growth has been slower since 2004. Based on this finding Decker, Haltiwanger, Jarmin and Miranda (2018, 2020)find that the dynamism in the U.S. economy has declined.[27] The gap between low- and high-productivity establishments has increased, consistent with the slowing of overall productivity growth.

The increase in the gap between the high and low productivity plants has also been found for other countries. A study from the OECD using an international database, led by Dan Andrews, found that the most productive companies were pulling away from the rest of their industry.[28] The best companies had continued to see productivity growth even when their industry on average had shown slow or no growth. This study suggested that the declining dynamism and slowing of competitive dynamics seen in U.S. data may also be true in Europe and elsewhere (except for the firms at the very top of the productivity distribution).

VI. Have the Key Questions Been Answered?

The first four questions posed in the second section of this study are all related. Research has found that overall productivity growth is tied to TFP and has been associated with technological progress. The answers to all four of these questions are tied to an understanding of TFP—where did it come from during the period of fast growth, why did it slow down (and then speed up and slow down again), and why does its level differ across countries? While not all the puzzles have been answered, there are lessons that have contributed to an understanding of them.

Innovation, broadly defined, must be the source of productivity growth for firms at the productivity frontier. Technological developments coming from science and engineering are one important source of innovation, but soft innovations are important also, often more important. These take the form of new business models, new products and redesign of old products, and improvements in existing processes. These innovations have contributed strongly to TFP growth over time. And differences in the application of these soft innovations help explain productivity differences across countries.

The path to a higher level of productivity for most industries in most countries is to learn about the best-practice innovations made around the world and take advantage of them. This applies to Japan, where there are lagging industries, but the United States also has lagging industries. In some cases, access to best-practice productivity can be limited by trade secrets, patents, or by the complexity of operating at the productivity frontier, but in most cases the necessary technology is available in the global market through capital goods suppliers, software suppliers, and business consultants. If it is too difficult for domestic companies to reach the productivity frontier, a country can encourage direct foreign investment to bring best-practices into their economy. At the beginning of 2022 the United States hosted over $14 trillion of foreign direct investment[29] mostly from leading global companies, including many from Japan.

Important reasons identified for the productivity gaps across countries are restrictions and regulations that protect companies with weak productivity, including restrictions on trade and investment. The nature of the restrictions that limit competition can vary across industry.

The business studies suggested the educational level of production workers may not be very important to achieving best-practice productivity. However, Germany has shown that high productivity can be combined with a well-trained workforce and this path provides greater equality for the workforce and greater opportunities for those people who do not obtain a college degree. Also, Baily, Bosworth, and Kennedy (2021) argued that advanced education is important for managerial skills, R&D, and innovation.

Although this study has not emphasized the issue, there is a consensus among economists that the period of rapid TFP growth in the United States that started in the mid-1990s and lasted until around 2004 was linked to information and communications technologies. In particular, the semiconductor industry was able to cram more circuits onto a single chip and increase the power of computers. Increased competition in this industry encouraged more rapid innovation. Improved computers and communications technologies also helped other industries to advance. Another large productivity contribution came from wholesale and retail trade, where big-box retailers expanded nationwide, coordinated their wholesale and retail functions, and pushed other companies to improve their own operations. By the early 2000s these sources of growth had faded, and growth slowed again. The drop in TFP growth in the computer and electronics industries since 2014, shown earlier, is one important sign of the ending of the technology-driven productivity surge.[30]

The biggest mystery that remains in productivity research is to explain why productivity growth has been so slow in recent years across so many economies. The default explanation for this is that the pace of productivity enhancing innovation has slowed as the best sources of innovation have dried up.[31] As we saw in Figure 2, the pattern of slow growth is widespread and long lasting. What remains puzzling is that it appears to many that the pace of innovation has not slowed at all but instead is extremely rapid, with advances such as artificial intelligence, machine learning, robots, 3-D printing, and so on, and new companies, like Amazon and Uber, that are shaking up traditional industries. Presumably, all the technological change taking place today is not the kind that generates strong positive productivity effects, at least not yet.

One important result is the very large contribution of the manufacturing sector to overall productivity growth and the very large contribution of the high-tech sector to manufacturing productivity growth. This result did not emerge from the 1990s cross-country studies, which focused on productivity levels (although subsequent research from the consulting company has emphasized the value of high-tech). This result also gave some insight into the slowdown in growth, a large portion of which comes from the slowdown in the high-tech manufacturing sector, as well as the reduction in the size of this sector as a result of outsourcing.[32] This finding also suggests a reason why the productivity growth that has been achieved has not done very much for regular workers. The high-tech sector, in both manufacturing and services, has generated huge wealth for some, but it has also increased inequality and has not created many good jobs for those without advanced education.

VII. Applying the Lessons to a Productivity Strategy for Japan

THE GROWTH PROBLEM IN JAPAN

Productivity growth has slowed very dramatically in Japan, as seen in Figure 2. Japan had one of the fastest rates of productivity growth among advanced economies for many years, but trend growth slowed throughout the ‘70s and ‘80s and, as shown in the figure, is now among the slowest. This productivity slowdown is also combined with very slow population growth; indeed, Japan’s population is currently declining, according to data from the United Nations. The combination of slow productivity growth and slow or declining labor force growth results in very slow growth in Japan’s GDP.

Of course, Japan is not alone in experiencing slow productivity growth and slow labor force growth. As we have seen, the United States and Europe share this problem. We do not know what future productivity growth will look like but at present everyone is in the same boat, learning to adjust to slow growth economies. Still, there are specific issues that Japan faces.

- Incomplete convergence. Whereas many European economies have caught up to the level of productivity of the United States, Japan has not. As we saw in Figure 3, there remains a substantial gap between the level of productivity in Japan and that of best-practice productivity economies. This statement applies to aggregate productivity. Japan still has very strong industries that are among the global productivity leaders, but it has other industries that are laggards.
- Need to develop human capital and talent. Japan’s education system excels at equipping students with basic skills, including mathematics. It performs less well in teaching students to think independently and to innovate. The labor market encourages students to achieve success by remaining with a single employer and moving up the job ladder through seniority.
- The challenge of slow or negative labor force growth. Like most advanced economies, the birth rate in Japan has declined, but the decline in Japan is substantial and the overall population has been declining since 2009.[33] The labor force has benefitted from rising employment of women but is likely to start declining in the future in the absence of any offsetting effect.[34]
- Need for leadership in advanced manufacturing industries. During the years when Japan’s economy was growing rapidly it led the world in many tech-

nology products, ranging from consumer electronics to machine tools. That leadership has eroded. Silicon Valley and other tech centers evolved in the United States and today China is using its huge size and resources to develop as the technology leader in Asia.
- The problem of global climate change has become acute. Japan has committed to reaching net carbon neutrality by 2050[35], which will take substantial investment and redirection of the economy, with the potential to slow economic growth unless offset by productivity improvements. This paper will not address the issue of climate change directly; however, it is an important background issue. Japan will be looking to meet climate goals even as it increases its economic growth.

There is concern in Japan that the economy is deteriorating. This is partly the result of comparison to other economies, particularly the emerging Asian giant of China, but also a concern that living standards have eroded for a significant part of the population. Wages have been almost stagnant for several years.[36] The overall GDP growth record is mixed. Real GDP fell sharply with the financial crisis and the Great Recession but then grew solidly until the third quarter of 2019. After that, the COVID-19 pandemic caused another period of GDP decline. Real GDP in Japan grew 5.4% from its peak in the first quarter of 2008 through its peak in the third quarter of 2019. In the first quarter of 2022, real GDP in Japan was 2.8% below its 2019 peak.[37] These growth numbers are slow, reflecting the slow labor force growth and slow productivity growth described above. Moreover, the challenges just listed are serious and threaten to limit or even reverse the growth that has been achieved. Abenomics[38] was helpful in terms of stimulating demand but did not make the structural changes that would move Japan onto a different growth trajectory.

As I stated at the outset of this paper, I have no wish to tell business leaders or policymakers in Japan what the country should do. This section is intended to offer ideas that I hope contribute to the discussion of economic policy and among business leaders within Japan.

IN OUTLINE: THE STRATEGY TO IMPROVE GROWTH

The main reason that Japan has failed to converge to the productivity level of the global leaders such as Germany and the United States is because there is a group of industries and (mostly small) firms that are protected against competitive pressure. Small firms lack the resources and skills to operate productively, while some larger firms do not face competitive pressure from global best practice companies and are able to make adequate profits without changing their operations.[39]

Japan historically has been one of the strongest performers and competitors in manufacturing, including high-tech manufacturing, but it has lost its edge in competing against the developing high-tech industries in China and elsewhere in Asia or with leading U.S. companies. The example of the United States shows the huge contribution that manufacturing makes to overall productivity, and historically, this sector has been central to Japan's economic success. Japan's high-tech sector still has strengths and can build on these to provide a source of growth for the whole economy. To strengthen manufacturing and high-technology, Japan will need to strengthen its educational system and its venture capital and innovation infrastructure.

Improvements in the educational system in Japan are important not just to improve the high-tech sector. Japan needs a more professional corps of managers able to enable a wide range of companies and industries to reach global best-practice levels of productivity. Japan's best companies remain outstanding, but this excellence must spread more widely throughout the economy. Japan must also take advantage of the skills of its production and non-supervisory workforce, as Germany has done. Japan has a tradition of producing high quality products and services, using its skilled workforce.

As noted above, Japan's population is now declining, although because of rising female labor force participation, the labor force has continued to grow. However, Japan is not making full use of women in the economy. Many of the women who participate in the labor force only work part-time and are in jobs that do not take advantage of their education and skills. To improve productivity and growth it will be important to provide women with greater opportunities in the labor market for good full-time jobs (for those that want them) and to ensure that promotions and opportunities are shared equally. This is something that Japan is committed to doing, and the opportunities for women are expanding.

What are the priorities among the policy choices? That depends on how large the payoff is and how difficult it is to make changes. Educational reforms are very important, and policymakers and companies have levers that can influence outcomes. These suggest educational reform should be a priority. Of course, it is bound to take time for such reforms to feed through to the labor force, so such reform will not change growth quickly. The greatest potential to finish productivity convergence to global best-practice productivity is to increase competitive intensity in the service industries, agriculture, and manufacturing industries that are protected from foreign competition. Such a change will face resistance, however. The best bet for politically-easier, rapid change is probably an initiative to strengthen innovation in the manufacturing sector.

JAPAN MUST CHOOSE WHETHER TO DISRUPT ITS LOW-PRODUCTIVITY INDUSTRIES

The experience of the United States shows that wholesale and retail trade can provide an important source for productivity growth, as demonstrated in Figure 4. This growth was the result of the expansion of productive retail formats of two types. First, the “big box” general merchandise retailers such as Walmart and specialty retailers such as Best Buy expanded. Second, smaller retailers became the outlets of large companies or were franchised outlets connected with large companies. These franchised retailers in the United States were often located in shopping malls to increase retail traffic and sales. The smaller stores could operate productively because the parent companies had the scale to manage purchasing and distribution. The same model has also been applied to restaurants and other consumer-facing businesses. A large parent company manages the back-office functions, can negotiate with suppliers, and create the IT systems used to operate the businesses. Advertising can also be handled by the parent company.

The transition to these higher-productivity formats for retailing and other businesses involves some social sacrifice. Shopping malls throughout the United States look very similar to each other and many of the same stores are found everywhere. There is a homogeneity that not everyone likes. The big box stores outcompete small, locally-owned retailers that find they can no longer stay in business. Traditional “main street” shopping districts face empty store fronts and the loss of local businesses.

Today, retailing is undergoing another transformation as online retailers, notably Amazon, are expanding and putting some of the big box retailers and the shopping malls under financial stress. The combination of Amazon and COVID-19 has resulted in many empty storefronts on main streets and in malls.

The experience of the United States is that, over time, there is an adaptation to new consumer formats. Some years ago, it seemed that there were video rental stores on every street corner. Then Netflix entered the industry and eventually streaming became the way people watched movies at home. The video rental stores all disappeared but were replaced by other customer formats, such as the fitness centers or beauty parlors that now seem to be on every street corner. More recently, the decline in independent retail outlets has been substantially offset by a rise in the number of restaurants. Of course, the pandemic has hit restaurants hard, but it is to be expected that they will return; indeed, this is happening already.

In short, the relatively easy regulatory environment in the United States has fostered flexibility, so that new formats for retailers and restaurants can respond to changing technologies.[40]

Another, albeit smaller, part of the economy where regulation has been important is agriculture. The number of farms in the United States was around 7 million in the 1940s and this number has declined to around 2 million today. Most agricultural production comes from large farms.[41] This change in the sector has had a big impact, pushing workers off farms and into cities. In the nineteenth century America welcomed settlers and had land grants to encourage people to start farms. Family farms were an important part of the country's history and there have been many efforts to save family farms, largely unsuccessful. At the same time, agriculture has been one of the most successful industries in America in terms of sustained productivity growth over a long period. It is a small industry today, but it has contributed to overall productivity growth historically.

In the study of productivity growth by Baily, Bosworth, and Doshi (2020), supported by the Japan Productivity Center, it was reported that wholesale and retail trade and agriculture were industries that had productivity below the level of the United States, and these industries were falling further behind because their productivity growth was slower than that in the United States. The food processing industry in Japan was also well behind the productivity level in the United States and its productivity was growing only marginally faster than the industry in the United States.[42] These industries in Japan have many small companies that are often protected by regulations or zoning laws. They have played an important role in Japan in providing jobs for older workers, but the price has been productivity that is below best practice. Should this situation be changed?

The traditional employment pattern in Japan was for workers to remain with their main employer until around age 60 and then move to work in smaller establishments, often small retailers, restaurants, or farms, often family businesses. Finding alternative employment was needed because people in Japan live a long time. In 2019, the life expectancy of a female in Japan at age 65 was 24.6 years and for a male the figure was 19.8 years.[43] On average, therefore, females who reach 65 were expected to live until age 90 and males until age 85. Since that is the average, many were expected to live even longer. Of course, the pandemic has impacted mortality, but once that is over, the normal life expectancy patterns should re-emerge. Given Japan's longevity, the traditional employment pattern served a valuable purpose, even though many of the small family businesses were not very productive. The small business jobs provided continued employment for workers that had left their regular jobs but were not ready to retire.

The old employment pattern is now changing with companies keeping their workers until age 65, and there are proposals for regular employment to continue to age 70. It would be helpful to Japan's economy to extend the duration of normal work beyond age 60, and to allow the option of working even beyond age 65 for those that choose to do so. Of course, some people suffer from ill health and cannot work into old age but having the option to work longer will help alleviate the labor shortage in Japan. Given that workers in Japan will no longer be forced to retire early, it will become possible to allow competition to work more effectively within the industries that are currently less productive. Easing regulation and zoning will allow the most productive companies to expand in industries such as retail, restaurants, and agriculture, even if that means some jobs will be eliminated. Not all the small establishments will disappear, of course, because there are some that have advantages of convenience or that are serving a particular niche market. Restaurants with good chefs will be able to survive in the face of competition from large companies and franchises. The goal should be that Japanese companies that see opportunities to expand their businesses should not be blocked by regulation, while consumers should be able to exercise choice over the type of restaurants or retail stores they wish to patronize.

Japan's people and policymakers will have to make a choice. Is it better to keep the low-productivity industries as they are and keep the existing regulations in place that discourage competition, or it is better to open markets, even if that disrupts many established small companies and closes off some employment options for older workers? Any changes would have to be made gradually to ease the transition costs.

IMPROVING THE RETURNS TO HUMAN CAPITAL

In a 2015 study of Japan, Desvaux et al. (2015) explored questions about the educational system and whether it could be improved and provide a more productive workforce.[44] Education is important for more than just productivity, of course; it allows students to expand their horizons, read great books, and form friendships. However, the economic function of education is vital and should be at the forefront of thinking about curricula and learning and teaching methods. The report noted that Japanese students are among the top 10 countries in the world in the PISA tests that measure mathematics and science capability, and top 15 in reading. There is no question that students finishing high school in Japan are well prepared in these subjects and score higher than American students in mathematics.[45]

A concern, however, is that Japanese students lack confidence in problem solving and taking on complex tasks. The report argues that the educational system in Japan stumbles in helping students develop the skills they can use in future employment, in developing critical thinking, in learning experimentation, and in increasing their ability to collaborate with others. The report also argued that students in Japan lack a global mindset. To a degree, English has become the global language, so that facility in English is an important ability for professionals and managers to access information from around the world. However, most Japanese students do not graduate with strong English language skills. The report also argues that Japan's economy would benefit if more Japanese students studied abroad and if it were made easier for foreign students to study in Japan.

Lessons from the Baily-Bosworth-Kennedy Study (2021). In work supported by the Japan Productivity Center, this research explored the returns to education in Japan, the United States, and Germany. The paper reported the level of educational attainment in the three countries, looking at years of schooling. Figure 8 shows the findings, taken from that study.

Starting in the 1950s, the United States had a substantial lead in years of schooling, both in average years of schooling in the population over 25 and in years of tertiary schooling (college and beyond). Since then, Japan has pretty much caught up with the United States in terms of average years of the over 25s, while Germany overtook the United States by this measure in the early 2000s. The average years of schooling in the United States has grown only slowly since around 1980. This reflects a problem of dropouts in U.S. education and an inflow of immigrants with low levels of education. The pattern in Germany is almost the opposite, with average years of schooling remaining flat at just under eight years through the 1960s and '70s before there was a big push on education in Germany starting in the mid-1980s. The rise in years of schooling has been particularly notable in Germany, and updated data from UNESCO now ranks Germany ahead of the United States.[46]

Germany has developed its apprenticeship programs which combined work experience with classroom learning. Their dual system of training is based on cooperation between mainly small- and medium-sized companies on the one hand and publicly-funded vocational schools on the other. Trainees in the dual system typically spend part of each week at a vocational school and the other part at a company, or they may spend longer periods at each place before alternating. Dual training programs usually lasts two to three-and-a-half years.

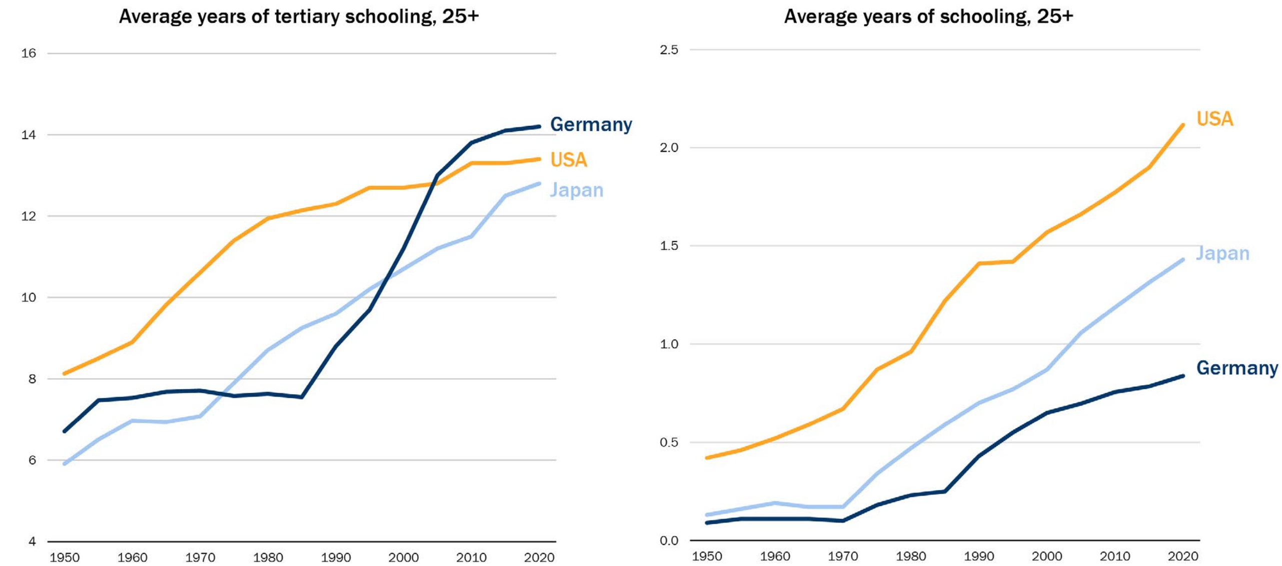
In terms of tertiary education, the United States leads with over 2 years of tertiary education on average in the over 25 population (see second panel of Figure 8). Japan has many students participate in tertiary education, but this is often in short-term programs. A surprisingly low proportion of Japan's population has master's degrees and Ph.D.s, which may be problematic in meeting developments in high tech. Germany has the lowest amount of tertiary education among the three countries (second panel of Figure 8).

Table 2, also taken from Baily, Bosworth and Kennedy (2021), shows additional information on the extent of secondary and tertiary education in the three countries.[47] This data from the OECD indicates that about

FIGURE 8

Gains in Educational Attainment

Germany, Japan, and the United States



Source: Barro, Robert and Jong-Wha Lee, 2013, "A New Data Set of Educational Attainment in the World, 1950-2010." Journal of Development Economics, vol 104, pp.184-98; and updated data from the World Development Report, 2020, and UNESCO.

half of the U.S. population has tertiary education (49% of the population, the sum of Short Cycle Tertiary 11%, bachelor's degrees 24%, master's 12% and Ph.D.s 2%). While the percentage is equally high in Japan, it is dominated by short-cycle programs, as shown in Table 2. Germany has the lowest proportion of the population with a tertiary education, but that is partly a reflection of its greater emphasis on vocational training programs. It is comparable to the United States in the proportion of the population with postgraduate degrees. The low proportion of the population with tertiary education in Japan may be a concern and may result from the pattern of lifetime employment, which makes it not worthwhile for students to extend their education.

We have noted that Japan does very well on the PISA tests of secondary school students. Further evaluation of secondary school performance is made by the World Bank's Human Capital Index, and their data for 2020 shows Japan with a very high international ranking at number three in the world, compared to Germany at 25 and the United States at 35.[48] As noted earlier, Japanese students emerge from secondary education with stronger skills on average than American or German students in mathematics and science. University education is different, however. Companies can design business systems to be productive even if their production and non-supervisory employees lack skills, as long as supervisors and managers can design and administer those productive systems. Rankings of universities are generally based on the research and publication records of the faculty and the number of patents awarded. Using these criteria, the United States is where half of the top universities in the world are located. The QS World University Rankings rank the U.S. higher education system as the world's best performing, with Germany fourth and Japan tenth.[49]

The report on education in Japan, cited above, argued that there may be concerns about the training Japanese students receive in tackling complex problems and working in teams. One way these problems may show up is in the financial return to college, and indeed this is what we found in the Baily, Bosworth, Kennedy (2021) study.

- On average, a male employee in the United States labor market with a college degree (a BA or similar) receives an earnings premium of roughly 44%.[50]
- A female employee with a degree receives a premium that is fractionally higher at 45%.
- The equivalent results for Germany show the male premium for a college degree is about 37% and 24% for female graduates.
- *Looking at the results for Japan reveals much lower premiums. For both males and females, the earnings premium for a degree is only 20%.*

The study also looked at employees who had continued their educations beyond college graduation.

- In the United States, the earnings premium for tertiary degrees is 72% for males and 73% for females. Those that continue their education beyond the bachelor's level in the United States are very often seeking professional qualifications such as a MBA from a business school, a law degree, or a medical degree. Those professional qualifications in the United States generally yield high earnings.
- The corresponding figures for Germany are 59% for males and 50% for females.
- In Japan, the earnings premia for advanced education are 47% and 44%. These figures for Japan indicate a good return from an advanced degree compared to a bachelor's degree or similar, but they are well below the premia achieved in the United States.

These results signal concerns about the preparation being provided by college education in Japan. In a market economy, a person's earnings reflect the additional or marginal product they can contribute to the firm that is paying them. Firms in Japan do not consider a college education or even an advanced degree to be very valuable to their operations, and hence they are not willing to compensate the employees that have received these levels of education with a wage premium in the way employers compensate educated workers in the United States.[51]

One aspect of these results should be clarified. The premiums received by females are similar in size to those received by males. However, this does not mean

Table 2: Educational Attainment of the Population, Ages 25-65 in 2019

Level of Education	Germany	Japan	United States
Primary	4		3
Lower Secondary	10		6
Upper Secondary	3	47	42
Vocational	53	(a)	(a)
Short-cycle Tertiary	1	21	11
Bachelor's Degree	16	31	24
Master's Degree	12	2	12
PhD	1	(b)	2
Total	**100**	**101**	**100**

Source: OECD. Education at a Glance 2020. Table a1.1, Educational Attainment, ages 25-64
(a). Vocational is included in upper secondary for Japan and the United States.
(b). Data for Japan are drawn for national sources and those with a PhD are included with master's degrees.

that men and women are paid the same in any of the three countries. Men, on average, are paid more at all levels of education. For those that have just completed secondary education, Japanese women make about 35% of male earnings. For those with graduate degrees, women make about half of the earnings of males. In other words, women on average earn much less than men in Japan, but the gap is smaller for women with more education. Hence, further education is helpful in boosting wages for women but does not ensure comparability with male earnings.

Ideas to Improve the Return to Education in Japan. Here are four ideas or suggestions, based on the prior discussion, that Japan can use to enhance the benefits it receives from its educational system.

- Starting in secondary schools, teachers can put more emphasis on problem solving and tackling problems in teams. Whether individually or in teams, students should be asked to explore new

ideas and learn how to think creatively. It is still important to acquire facts, of course, but with access to computers it is more important to learn how to find information and decide what information is most important to solve a problem. The skill students need most is how to think rationally and creatively.
- Schools and universities could work with Japanese companies to design curricula that will develop the skills that companies are looking for in their workforces. This is a more controversial idea, in that there should be a separation between educational institutions and business. However, given that companies are not satisfied with the skills that students acquire, particularly the skills they acquire in universities, it is important to explore a closer connection between educators and business leaders. Educators should know more about what companies value and what they are looking for in the students they hire. When millions of students spend years being educated, it is vital for economic growth in Japan that the students emerge from their education with the skills that will allow them to contribute to the economy and achieve the satisfaction that comes from a successful and well-paid career.
- Internship programs where students spend the summer or even a full year in a company learning would help students learn about workplaces and what they will need to learn to do well in employment.
- Today, Japan is missing out on the economic return that the female workforce can provide, although that is changing. Traditionally women were expected to give up employment after marriage, concentrate on raising children, and make the home for their husbands. As a result, companies did not view women as good material for training and promotion to more responsible and better-paid jobs. Today, the level of labor force participation of women in Japan is high and millions of women are looking for good jobs that provide satisfaction and economic rewards. In return, women can provide to the Japanese economy educated workers with strong skills and the ability to manage other employees, to innovate, and to run companies. Increased female labor force participation has already helped overall economic growth by increasing the growth of the labor force, but there is more that can be done, indeed more is being done. The government of Japan is requiring that companies publicize wage differences by gender to encourage greater equality. In the past many women worked only part-time in jobs that did not exploit their strengths. That is now changing and promotions to good full-time jobs are becoming more available to all women that want careers. Changing attitudes is difficult, however, and it may take some time for full equality to be achieved. The potential payoff is large.

There might well be pushback against some of these suggestions. Professors and academic institutions have guarded their independence and believe it is important to separate learning from the immediate needs of the workplace. And, of course, it is important that students acquire general skills that can serve them throughout their lives and not just narrow skills for a specific job or even a particular industry. There must be a balance struck between the returns from pure education and the returns from knowing the skills needed for a job. At the moment, however, it appears that the Japanese educational system is not providing students with the capabilities they need. After all, critical thinking, dealing with complex problems and learning experimentation are all general skills, valuable in many occupations not just in corporations.

One additional idea, taken from the consultants' report on Japan, is for a workforce productivity agency of the type that has been developed in Australia. The report notes that Japan does not have a good match between the jobs available and the skills of the workforce. They say that there are too many workers for the available jobs in manufacturing and too many workers looking for traditional office jobs, while there are not enough workers available in services and health care. The proposed agency would evaluate the labor market and see where the surpluses and shortages are to be found.

This study provides only suggestions about educational reform in Japan. Moreover, the problems in the American education system are very apparent. It suffers serious problems of its own, notably in its secondary schools, and cannot be used as a model for other countries. However, given the concerns about the lack of economic growth in Japan and the need to develop strength in innovation, it is important for business leaders, educators, and government leaders to evaluate major reforms to the educational system that would help graduates get good jobs and be more productive.

The last pillar of the strategy to enhance productivity in Japan involves the manufacturing sector, particularly advanced manufacturing. We turn to this in the next main section, as follows.

VIII. Improving the Performance of Advanced Technology and Manufacturing in Japan

We have seen earlier in this paper that manufacturing plays an important role in driving productivity growth in the whole economy. In the United States, manufacturing was by far the largest contributing industry to overall TFP growth in the business sector. Moreover, the computer and semiconductor industries accounted for most of manufacturing TFP growth over the period. The experience in the United States also shows reason for concern as TFP growth collapsed in the few years prior to the COVID-19 pandemic—this was before the pandemic started.

Japan's economy has a history of strong performance in advanced manufacturing. The automobile industry became a world leader with excellent cars at affordable prices. Japan also developed a leadership position in electronics, with integrated circuits, gaming consoles, flat-panel televisions, and Blu-ray technology. Japanese companies have also been strong in machine tools and industrial machinery. There remains much strength in Japanese manufacturing and product development, where companies achieve very high quality through design and incremental improvements.

In the United States in the 1980s and '90s there were efforts to limit imports from Japan with concerns that Japan's industrial model was taking over and driving American companies out of the market for advanced manufactured goods. Restrictions on imports from Japan forced Japanese auto and electronics companies to invest in plants in North America to avoid the tariffs and quotas.

The concerns about American performance in manufacturing that were triggered by Japan's successes have proven well-founded. Most of the U.S. manufacturing industry has not performed well, although there are areas of continued strength. Employment in U.S. manufacturing has declined from 19.64 million in 2000 to 15.74 million in 2019, and further to 15.56 million in 2021.[52] The United States runs very large trade deficits in manufactured goods.[53] However, U.S. companies have been able to retain technological leadership in many areas even though the manufacturing is not taking place in North America. U.S. companies often contract out manufacturing to plants in other countries. Business strategy in the United States has emphasized an "asset light" approach, where investment in fixed assets is minimized and, in some cases, labor costs are reduced by production in low-wage economies. For example, Apple has become one of the most valuable companies in the world, but it produces its products under contract, mostly in China, with components made in Taiwan and elsewhere in Asia (including Japan). Apple controls product designs, marketing, and sales, and collects most of the profits.

Silicon Valley and other U.S. technology centers are very successful and generate employment and wealth, but they focus mostly on ideas, not on manufacturing. The manufacturing sector that remains within the United States is lean and productive but only a small part of the economy. There are remaining strengths in this industry, in aerospace, for example. And there may be some reshoring of manufacturing, given increased global tensions and the conflicts with China. But manufacturing in the United States will remain small compared to the overall size of its economy.

Japan has also lost ground in manufacturing globally and in employment. The sector had 12.02 million workers in 2002, falling to 10.63 million in 2019 and to 10.37 million in 2021.[54] And Japan has not achieved the same success achieved by Silicon Valley and other U.S. technology clusters. One of the industries that has been difficult for Japan has been computers and electronics, where Japanese companies have lost market share to South Korean, Chinese, Taiwanese, and American companies.[55] Going back a few decades, Japan had both successes and failures in its major R&D efforts in this area. From 1975-85 cooperative R&D among Japanese companies and the government saw success in the "very large-scale integrated circuit" (VLSI) project, which resulted in Japan becoming a global leader in this technology.[56]

In the computer and chip industry, however, Japan saw IBM and its dominance of mainframe computers as the target for its own industrial strategy and put resources into developing a mainframe industry. It developed excellent mainframe technology but did not anticipate the shift to personal computers and the rise of Microsoft and Intel. Nor have Japanese companies played a major role in recent developments in computer chip design. A new design approach has been developed based on RISC technology from the University of California at Berkeley. This has been operationalized by the UK design company ARM[57], together with Apple and Nvidia. The new designs are ubiquitous in mobile devices and are becoming a major competitor to Intel's computer chips. Japanese companies are making use of ARM designs. For example, Fujitsu has used ARM chip designs to produce a top ranked supercomputer able to make billions of calculations per second.[58]

In the automobile industry, Japanese companies remain very strong globally but face challenges from Hyundai/Kia from South Korea, from emerging Chinese companies, and from the American company Tesla in battery-powered electric vehicles. Tesla has by far the highest market value of any auto company. Toyota pioneered hybrid vehicles and remains a world leader in this technology, but it bet on the development of fuel cell vehicles as an alternative to battery power (the Toyota Mirai). Fuel cell cars are currently considered a failure although hydrogen-fueled buses and heavy vehicles have more potential.[59] Japanese and German auto companies remain the largest worldwide but both industries will need continued successful innovation to remain leaders.

IMPROVING CAPITAL INVESTMENT IN JAPAN

Research into productivity growth showed that capital investment and the increase in capital intensity over time was not as important a source of productivity growth as had been thought prior to Solow's famous 1957 work. However, that does not make capital investment unimportant. Figure 1 shows that capital contributed substantially to economic growth in the United States in all past periods and continued to be an important source of growth when TFP growth had declined. In the study by Baily, Bosworth, and Doshi (2020) we found that weak capital investment had contributed to the slow overall growth of productivity in Japan in recent years. Boosting the level of investment is an important strategy to increase overall growth and especially important to manufacturing. Can that be accomplished?

The lack of capital investment has been attributed to the fallout from Japan's financial crisis at the end of the 1980s, where companies and banks both suffered setbacks. And that diagnosis is surely correct for at least the first half of the 1990s. However, the persistence of low investment levels suggests there are other factors at work. First, capital investment tends to follow new technologies and business models. Rapid TFP growth stimulates rapid capital growth, so that the slowing of TFP growth has had a depressing effect on investment.

Second, investment is impacted by the cost of capital. There are two elements to this cost: One is interest cost, or how expensive it is for companies to borrow to make investments, and another element is the performance of equities. When the stock market valuation of companies is high, this allows them to use retained earnings to finance investment and, as needed, issue new shares to finance expansion. Company CEOs are more willing to take risks on new investments when their share price is strong. The rate of interest in Japan has been very low, so that borrowing should not have been a barrier to investment once the financial sector recovered. However, the price of equities was hit very hard in the crash of the early 1990s and has taken a long time to recover. It is likely that a culture of greater caution has become embedded in companies in Japan, which is holding back investment.

Another reason for slow investment comes from slower growth in the labor force. If the labor force is growing rapidly, then new investment is required simply to equip workers with the level of capital that already prevails. That can provide a growth advantage if new capital goods embody the latest technology and, conversely, slow labor force growth can provide a drag to growth. In addition, many companies have determined that they must set up production facilities overseas to compete internationally rather than producing only in the domestic market. There are different reasons for this, including trade barriers facing Japanese exports and concern about a shortage of workers in Japan.

Some of these reasons for slow investment cannot be changed, but others can. The most important key to spur investment is to spur innovation, and that is discussed in the next section. Another boost to investment can come from making better use of women in the workforce. Overall labor force growth in Japan has been sustained by the increased participation of women, but too often women are in low-level and part-time employment. They are not seen as full participants in a company's workforce. As that is changed and women are given the opportunity to fill the jobs that men have traditionally performed, this will encourage investment. Encouraging immigration into Japan would also help alleviate worker shortages.

INNOVATION AND R&D IN JAPAN: PROBLEMS AND POTENTIAL SOLUTIONS

Despite the frustrations just described, Japan's innovation effort remains very strong in terms of R&D. Japan remains one of the leaders with over 3% of its GDP invested in R&D[60], pretty much the same as the United States and Germany (the U.S. percentage jumped in 2020 with the large increase in money for vaccine research).

The World Intellectual Property Organization has developed a Global Innovation Index to track the performance of 173 advanced and emerging economies in innovation. Their 2021 index ranks the United States third in the world behind Switzerland and Sweden. Germany is ranked tenth and Japan is ranked thirteenth, behind the UK, Korea, Singapore, France, and China.[61] This organization provides a tabulation of the factors they consider important to successful innovation. They note several strengths of Japan, including the amount of R&D (together with the amount performed by business and proportion of the research talent in business), the rate of e-participation, the amount of domestic credit to the private sector, the scale of the domestic market, the number of patent families, the amount of intellectual property receipts, the complexity of production and exports, the cost of redundancy dismissal and the ease of resolving insolvency. They also point to weaknesses, including ease of starting a business, expenditure on education, percent of graduates in science and engineering, the ease of getting credit, the size of tariff rates, the amount of R&D financed from overseas sources, inflows of foreign direct investment, labor productivity growth, and the number of new businesses. These were weaknesses compared to the full set of economies, but there were also some further weaknesses in comparison to other high-income economies, including enrollment in tertiary education, venture capital deals, joint venture deals, scientific and technical articles published, and several measures of online creativity.

One sign of the difficulties currently faced by Japan in its innovation efforts is the pattern of patent filings. Japan holds important patents in battery technology, robotics, and many other areas, and in the early 2000s Japan filed more patents than did the United States or the whole of the EU. However, from 2000 to 2019 the annual number of patents filed in Japan fell by 1.7% a year, compared to a 4.3% a year rise in the rate of patenting in the United States.[62]

A study by Arora, Branstetter, and Drev (2010) argued that one reason for problems in the Japanese IT industry was the shift from hardware to software innovation. The Japanese industry had focused heavily on developments in hardware whereas the industry in Silicon Valley had shifted more towards developments in software. As hardware matured and the pace of Moore's Law slowed down, the potential for innovation moved to the ways in which the software can be used to provide innovative business and consumer products. The Japanese industry fell behind in making this shift, the authors argue, and they suggest problems with human resources were the reason for this.

China is a rising presence in innovation, pouring money into research attempting to become an innovation powerhouse. China had a 10%-per-year rate of increase in its patent filings 2000-19 and now files more patents than all the other main countries combined. Many Chinese patents are filed to seek research funding or promotion and are not of much value. One commentator said that 90% of Chinese patents “are trash.”[63] Still, China has such vast resources that it can afford to waste money as it develops its innovation skills. China’s ambition is to become the global innovation leader.

It is important not to place too much emphasis on patents. Many productivity-enhancing innovations are made through soft innovations, as was noted earlier. However, the declining rate of patenting is one sign that Japan may no longer be receiving value for money from its large investment in R&D.

What can be done to improve the performance of R&D in Japan? One concern about R&D in Japan is that companies have a non-labor cost base in their R&D programs, which means that the R&D process itself in Japan is not very productive. The higher cost base is the result of inefficiencies in global operations and supply-chain management.[64] This suggests the R&D process itself in Japan could be made leaner and more productive. Also, the work by Brookings colleagues Dany Bahar and Selen Őzdoğan (2021) for the Japan Productivity Center argued that part of Japan’s weakness in R&D comes from its weak collaboration with global partners and researchers. They also note that foreign researchers who might come to Japan face a high barrier in terms of cultural and language differences.

A study by the Bank of Japan pointed to three factors that may be holding back Japanese R&D performance. First is the focus on incremental improvements. This strategy has served Japan well in many cases and been a key factor in the world-leading strength of the Japanese auto companies, but it has the disadvantage that major breakthroughs can be missed. A second issue is around a lack of interaction with customers, which can lead to new products that do not meet the needs of the customers. Third is a lack of collaborative innovation with different companies working together or working with outside research institutions.[65] These points from the Bank of Japan are helpful, but the argument that Japan has only focused on incremental innovations can be questioned. The project on VLSI development was a major technology push that was successful. The program to develop a stronger mainframe computer industry was also a major effort but one that did not pay off as hoped. R&D projects are always uncertain, and the key to success is to remain flexible and respond to changes in the market or in the direction technology is taking. It is not necessary to be the first to innovate.

It is easy to think that the first company to make an important innovation can then dominate the market, but that is often not the case. There were several search engines developed in the early 1990s, such as Aliweb, WebCrawler, Altavista, and Yahoo.[66] Google was able to create a better search engine, as was Baidu in China, and they now dominate the industry. Blackberry created a terrific smartphone that achieved great success before Apple introduced its own smartphone. Success in innovation comes from responding to changing markets and conditions.

A report by McKinsey, the consulting company, assessed avenues to improve R&D in Japan based on three main points.[67] First, Japan must meet the challenges of digitization. Companies around the world are working to use new digital technologies to streamline workflows and facilitate efficient information exchange among teams, among different parts of the business, and with customers and other external actors. A survey of CEOs globally reported that less than 15% of them thought that digital transformation programs had led to sustained performance improvements. A survey of Japanese R&D executives reported that only 45% had a clear strategy for the digitization of their internal operations. Introducing new digital tools faces the problem of legacy systems already in place, that are often not internally compatible and not compatible with the new systems being introduced. Existing staff are often reluctant to make big changes since they are heavily invested in knowing about the systems already in place.

The second issue is around speed of response. The argument made is that too many Japanese companies do not embrace the idea of being agile in their responses to changing circumstances. Japanese companies, it is argued, have embraced incremental innovation to the point they find it hard to change direction when market forces demand it. (This point is related to the argument just made above.) Japanese companies are usually hierarchical and do lengthy planning before executing a project. In manufacturing the culture is based on freezing specifications early to smooth the transition from development of a prototype to subsequent high-volume production. This culture clashes with what is needed with the adoption of emerging digital technologies, which requires agile working methods.

The third issue is talent. In 2020 there was a shortage of 240,000 skilled IT professionals in Japan, a number that is expected to rise to 600,000 by 2030, with bigger shortages in software engineering and project management. Some of the most talented graduates in digital technologies are more interested in jobs in exciting new areas like artificial intelligence rather than in traditional engineering companies. To ease talent shortages, companies can do more to screen their projects, eliminating those that are unlikely to yield good returns while keeping a focus on projects that can lead to major new product lines. Companies need to decide what their future could look like and determine which projects will help them reach this goal. Seeking out collaborators is another way to improve performance and ease skill shortages. Collaborators can bring capabilities with them that augment the skills and capabilities already available, and this is especially important in moving to more advanced development platforms and software development.

DEVELOPING A STRONGER VENTURE CAPITAL INDUSTRY IN JAPAN

In Baily, Bosworth, and Kennedy (2021) we said that in the United States over the past half century, venture capital (VC) has emerged as an important alternative source of financing for high-potential startups that are focused on the commercialization of risky new ideas and technologies. VC-backed firms accounted for about half of the initial public offerings (IPOs) in the United States between 1995 and 2019 (Lerner and Nanda, 2020). Several of the country's largest corporations relied on venture capital financing in their formative years. VC-backed firms also have represented about 90% of the R&D spending reported by all IPOs.[68] According to the OECD, venture capital investments amounted to $164 billion in 2019, and 82% of these investments were in the United States. However, at the scale of the total economy venture capital investments remain small even in the United States, representing about six-tenths of a percent of GDP.[69]

Where does venture financing come from in the United States? The liberalization of regulatory restrictions on pension fund investments played an important role in the initial growth of the VC market in the United States, but in recent years VC funds have attracted very diverse funding—including public and private pension funds, insurance companies, individuals, university endowments, and foundations. Typically, a venture capital firm will create a limited partnership with the investors as limited partners and the firm itself as the general partner. Each fund is a separate partnership with a lifespan of 7 to 10 years. The payoff comes after the company is acquired or goes public. A fraction of fund exits are the result of an IPO but most (92% 2004-20) are through a merger or acquisition (M&As). In addition, the U.S. has experienced significant growth in corporate venture capital funds (CVCs), which accounted for about 20% of overall VC activity in 2018.[70] CVCs are established with the objective of investing a firm's funds directly in new external startups as opposed to being a limited partner in venture capital funds managed by others.

Venture capital investment in Japan has been much smaller than in the United States, equal to $2.5 billion in 2019 according to the OECD, compared to the U.S. figure of $135.6 billion. While the level of investment in startups remains small in Japan, they have expanded rapidly in recent years. Tokyo-based data tracker Initial Inc. reports start-up funding increased seven-fold over the seven years through 2019, up to $4.8 billion.[71] The expansion has been encouraged by the liberalization of regulations that previously limited such activity. In contrast to the diversity of funders in the United States, banks, and nonfinancial corporations account for about 60% of venture capital funding in Japan. Unlike the United States, the IPO remains the dominant form of exit because acquisitions of outside firms and their culture continues to have a negative connotation in Japan. Cultural factors, broadly defined, appear to be the major barrier to the growth of innovative small firms. One of these factors is the stigma associated with failure. In Silicon Valley, it is seen as normal for an entrepreneur to have experienced one or more failures in the past. Inevitably, many risky projects are going to fail but the successes will pay off and cover the cost of the failures. In Japan, the failure of a company is seen as very negative and makes it hard for those that have worked in the company to get future funding.

One sign of the limitations of startups in Japan is the small number of "unicorns," which are startup companies with valuations of $1 billion or more. As of July 2022, there were 1,100 unicorns around the world with only six located in Japan.[72]

The Japanese government has been working to expand the availability of venture funding. For example, the government-owned Japan Investment Corporation created a $1.2 billion fund in 2020. One obstacle to expanding startups in Japan is a shortage of young entrepreneurs willing to undertake the risks of forming a new company. So-called "spousal block" describes the opposition of family members to a young person wishing to join a startup rather than a well-established company. The entry of organizations such as the Japan Investment Corporation may give greater credibility to the startup culture and encourage young people to join new companies.[73]

An optimistic view of venture capital in Japan is expressed by Motoya Kitamura (2021), the founder and CEO of Northvillage Investment. He argues that there have been fundamental changes taking place in the environment in Japan. First, there has been the emergence of new Asian role models for young people who have achieved success with startup companies. He lists Masayoshi Son of Softbank, Hiroshi Mikitani of Rakuten, Yusaku Maesawa of Zozo and several others. Second, large companies in Japan are creating their own venture capital subsidiaries, such as Dentsu, ANA, Sony, and KDDI. He also sees the emergence of independent incubator funds, which are small but are becoming important for startup companies. Third, is the increase in angel investing. This is something new in Japan – now, there are wealthy investors looking for opportunities and investing in multiple startups. He points out that Japan has the third largest population of millionaires in the world, and that negative interest rates are encouraging investors to look for higher returns. Kitamura also points out that the Tokyo Stock Exchange has announced reforms to streamline its trading markets, including a growth section for startup companies with growth potential, in contrast to the emphasis in the past on stability and maturity.

Kenji Kushida is a senior fellow at the Carnegie Endowment for International Peace in Washington, D.C. and the leader of their Japan-Silicon Valley Innovation Initiative. He argues the importance of U.S.-Japan cooperation in innovation.[74] The first challenge, he argues, involves finding the funding needed for innovation while at the same time ensuring there are incentives for the private sector to contribute. He supports the model that has been used both in Silicon Valley and other U.S. research hubs, such as Cambridge Massachusetts and Research Triangle in North Carolina, where government provides funds for universities and research labs and then the resulting technology developments are moved into startups in the private sector. He then argues for collaboration across the Pacific between Japan and the United States. He notes that developing successful startups requires not only venture funding and the startup companies but also large companies that are willing to buy the startups as they mature, flexible labor markets, and support in the form of law firms, accounting firms, and incubators. He points out that U.S. regulations restricting the involvement of foreign entities in U.S. technology companies is a barrier to U.S.-Japan cooperation. There are corresponding barriers for U.S. technology companies that want to operate in Japan.

The case made by Kushida for U.S.-Japan cooperation can be broadened. As suggested earlier in this paper, Japan could benefit from a deeper international involvement where more people are fluent in English and have experience living and working outside Japan.

While VC investments have also grown in Germany and it is the leading source of VC financing within the EU, the volume of investments as a share of GDP is only slightly larger than in Japan and less than a tenth that of the United States. There is a much higher incidence of startups with a valuation of $1 billion than in Japan. In addition, the German economy has many small and medium-sized manufacturing companies (the Mittelstand companies). These companies are successful innovators despite their modest size. They find the resources to innovate by a focus on niche products, they mostly make incremental innovations, and they have constant interaction with customers to determine where innovations will be successful (De Massis et al. 2017). These small companies are export oriented.

Based on this review of the literature, a summary of the steps that should be taken to enhance the success of venture capital and startup companies in Japan is as follows:[75]

- Increase the available venture capital funds coming from government, large companies, wealthy investors, and foreign sources. Tax incentives can be used to achieve this—the experience of Israel provides an example.
- Work with universities and research labs to change the attitude of young people towards working in small and startup companies. Attitudes towards company failures need to change.
- Review the regulatory environment in Japan to ensure that startups are encouraged. It should be easy for successful startups to exit, whether via acquisition or IPO.
- Foster business incubators. This has been done in several locations in the United States, such as New York City, Boston/Cambridge, North Carolina, and Silicon Valley.
- Promote an increased international perspective where Japanese entrepreneurs, engineers, and scientists are connected to innovative activity in Asia, the United States, and Europe.

Conclusions

While there remain unknowns, research into productivity has reached important conclusions that can provide a better understanding of the sources of growth and how business and labor leaders as well as government can contribute to faster growth. Even modest improvement in the rate of productivity growth can accumulate over time to generate substantial improvements in living standards.

Japan has an almost unique opportunity to improve its productivity growth rate and complete its catch-up to the level of productivity achieved in countries such as the United States and Germany. Japan has many world-beating companies, but it also has industries that remain protected by regulations and trade and investment restrictions. More broadly, it is important for Japan's business leaders to adopt an international perspective and make sure they are adopting best practice productivity measures wherever they are found. The fate of the Big Three auto companies in the United States provides a warning of what can happen if companies become insular and resist change.

Japan must also change its start-up and innovation culture. In today's highly competitive global economy, taking risks is imperative. That means companies and individuals must be willing to fail. Creative people who are creative and start new businesses should be rewarded even if those companies end up failing. Lessons learned from failure are valuable and can point the way to future successes.

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END NOTES

1 The theory of growth was developed by Solow (1956) and Swan (1956). Solow (1957) estimated the contribution of capital to growth. A new way of analyzing growth was developed by Romer (1986), but this has not changed the main conclusion from Solow (1957).

2 Jorgenson's research is summarized in his Harvard University page (Jorgenson, 2022)

3 Denison's research is described in Kendrick (1993).

4 Economic convergence is explored in Baumol et al. (1989) and Baumol et al. (1994).

5 Domar (1961).

6 This manual is updated regularly, see https://www.oecd.org/sdd/productivity-stats/2352458.pdf

7 Activities in the United States are assigned to industries on the basis of the most important activity in the establishment surveyed. Facebook, Netflix, and Google are all service industries, business or consumer services. Apple no longer manufactures in the United States. Amazon is primarily in the wholesale and retail industries. See the discussion below of the FAANG companies.

8 Netflix now faces greater competition in streaming from Disney, Warner/Discovery/HBO, and others. Google has changed its name to Alphabet and Facebook has changed to Meta.

9 Amazon also operates a streaming service, Amazon Prime, that is part of the communications industry and included in services in Figure 4.

10 There are also concerns about Amazon's treatment of small companies that use its distribution services.

11 Michael Mandel of the Progressive Policy Institute has commented on the impact of online sales, arguing that productivity is understated. However, he has not been able to make an estimate of the magnitude of any understatement, (Mandel 2017).

12 I was helped greatly by former government economists/statisticians David Byrne (now at the Federal Reserve) and Marshall Reinsdorf.

13 Baily and Looney (2017) based on research by Guvenen et al. (2022).

14 Byrne et al., (2016).

15 The group, the McKinsey Global Institute, was and is funded by McKinsey & Company, a profit-making institution, but as a research group whose results would be published and made available to everyone. The project reports are available on its website. The studies were also discussed in published articles, including Baily (1993), Baily and Gersbach (1995), Baily and Garber (1997), Baily and Zitzewitz (1998), Baily and Solow (2001), Baily et al. (2005), and Lewis (2004).

16 Francis Bator left the advisory group in the mid-1990s. He was the one who suggested the causal framework that was then used in all the productivity studies.

17 Baily and Zitzewitz (1998).

18 Rauweld (2021) describes the speech made by VW CEO Herbert Diess.

19 Bughin et al. (2018)

20 Some big box stores have skilled workers on the floor. Hardware store employees, for example, must provide advice and guidance if the store is to attract non-expert customers and the same is true for computer retailers and some parts of consumer electronics retailing.

21 Angrist and Kreueger (1991)

22 Ashenfelter and Kreuger (1994)

23 A former Goldman Sachs analyst, David Atkinson, who is originally from England but now lives in Japan and studies and writes about its economy, see https://www.wsj.com/articles/japans-new-economic-policy-guru-an-englishman-who-restores-temples-11608814800 Atkinson argues that Japanese companies are increasingly taking the "low road" in employment policies in Japan. His writings are in Japanese and so I can only report what others tell me of his thinking.

24 The details of the index are described in Gersbach (1999).

25 Measuring this contribution can be tricky as it involves assessing quality differences. However,

international comparisons try to make this comparison using products that are standard across markets. Then the price premium for higher quality products can be included in real output and hence in productivity. The OECD in its comparisons tries to use this approach and MGI made its own estimates.

26 Since this study was carried out there has been a proliferation of small-scale breweries in the United States, competing against the giants such as Budweiser and Miller. This does not undermine the argument made for Germany. The key question is whether high-productivity large-scale breweries are permitted to compete in the market. If they can, but consumers choose to buy beer from small local breweries, then the local industry is productive and efficient. The higher price of the local breweries allows their quality-adjusted productivity to match the large-scale producers.

27 Decker et al. (2016)

28 Andrews, Criscuolo, and Gal. (2016)

29 Data from the U.S. Bureau of Economic Analysis, https://www.bea.gov/sites/default/files/2022-06/intinv122.pdf

30 An alternative view of the speed-up in technology is described in Lewis et al. (2001). This study stresses the importance of increased competition and the pressure on retail productivity from the expansion of Wal-Mart.

31 See Gordon (2016). Further analyses of the slowdown are in Byrne et al. (2016) and Baily and Montalbano (2016).

32 Dale Jorgenson highlighted the importance of high-tech manufacturing to growth and suggested that as Moore's law is exhausted, that will lead to slower overall growth. I learned this from a presentation of his that I attended a few years ago, but I have not been able to locate a specific reference where he stated this. There is an analysis of the sources of growth in Japan in Jorgenson et al. (2018).

33 The COVID-19 pandemic has impacted population in Japan, as in other countries, see data at https://worldpopulationreview.com/countries/japan-population

34 Japan labor force data are available in English at https://www.stat.go.jp/english/data/roudou/lngindex.html

35 Lies (2020)

36 Data reported by the St Louis Federal Reserve, https://fred.stlouisfed.org/series/LCEAMN01JPA661S

37 Data reported by the St Louis Federal Reserve, https://fred.stlouisfed.org/series/JPNRGDPEXP

38 For an explanation of Abenomics, see McBride and Xu (2018)

39 A discussion of the productivity drag from small enterprises is in Colacelli et al. (2019).

40 The U.S. regulatory framework is far from perfect. For example, many workers must acquire licenses before they can work in many small businesses. See Nunn (2016).

41 https://www.nass.usda.gov/Charts_and_Maps/Farm_Labor/fl_frmwk.php

42 Baily, Bosworth, and Doshi (2020), Data from Appendix figure 3.

43 Data from the OECD, Life Expectancy, accessed 6 January, 2023. https://stats.oecd.org/

44 This was a study by the McKinsey Global Institute.

45 The most recent report on the Programme for International Assessment (PISA) came out in 2018, after the MGI report appeared, but the findings are comparable. See Schleicher (2018).

46 The most cited set of data on school attainment is available in the Barro and Lee (2013) dataset, which reports mean years of school (MYS) at five-year intervals and by age groups; but the latest year that they report is 2010. UNESCO has updated some of that data for more recent years, but the sharp rise in MYS for Germany after 1995 is puzzling and not reflected in an alternative data set from the OECD on the distribution of the population by levels of schooling attainment. The Wittgenstein Centre publishes a third dataset developed by Goujon et al (2016).

47 In the paper by Baily, Bosworth and Kennedy (2021), the information shown here is contained in Table 1.

48 World Bank (2020).

49 https://www.topuniversities.com/system-strength-rankings/2018

50 As discussed in Baily, Bosworth, and Kennedy

(2021), Table 3, the results are based on a specification using natural logarithms. The coefficient for males is 0.44 compared to the baseline of a high school graduate. Percentages and logarithmic differences are not the same, but the percentage figures give a reasonable sense of the earnings gaps among the groups.

51 Japan is more egalitarian than is the United States. There is discontent among American workers with only high school degrees about their inability to obtain middle-class incomes, afford health care, and a house or apartment. We are not suggesting that all is well in the U.S. labor market.

52 Data from the OECD website. Employment by activity, doi: 10.1787/a258bb52-en. Accessed on 06 January 2023.

53 Trade data is provided by the U.S. Bureau of Economic Analysis. https://www.bea.gov/data/intl-trade-investment/international-trade-goods-and-services

54 Data from the OECD website. Employment by activity (indicator). doi: 10.1787/a258bb52-en (Accessed on 06 January 2023)

55 Yoshida (2013).

56 Sakakibara (1997)

57 Chisnall (2010)

58 Fujitsu Limited (2022)

59 Frangoul (2022)

60 This figure is taken from Baily, Bosworth, Kennedy (2021)

61 https://www.wipo.int/edocs/pubdocs/en/wipo_pub_gii_2021.pdf page 100.

62 Data from the World Intellectual Property Organization reported in Chokki et al (2020).

63 He (2021).

64 Desvaux et al. (2015)

65 Nakamura, Kaihatsu, and Yagi (2018)

66 Hendy (n.d.).

67 Chokki et al. (2020)

68 Mergers and acquisitions (M&As) are an increasingly popular alternative to IPOs by which investors can exit their positions in venture-backed companies.

69 From OECDstat, OECD Entrepreneurship Financing Database: Venture Capital Investments.

70 National Venture Capital Association (2021)

71 Reported by Dvorak (2020).

72 See The Complete List of Unicorn Companies, July 2022, https://www.cbinsights.com/research-unicorn-companies

73 Dvorak (2020)

74 Kushida (2022).

75 See the McKinsey perspective on promoting a startup culture in Chokki et al. (2020).

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