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Productivity Improvement and Economic Growth

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Abstract

This paper summarizes recent discussion on labor productivity which is the source of medium- to long-term economic growth and observes the characteristics of recent productivity developments using relevant statistical data. Furthermore, the paper examines the background of recent Japan's low labor productivity growth and analyzes issues regarding Japan's sustainable growth.

Labor productivity in major advanced countries has been experiencing a slowdown in recent years. This is mainly affected by the slowdown of Total Factor Productivity (TFP). In Japan, there are two reasons behind the slowdown: first, technology and ideas accumulated by research and development (R&D) and management resources such as capital and labor are not utilized efficiently; and second, these resources are not efficiently reallocated among corporations.

In order to improve Japan's productivity in the medium to long-term, it is desirable to encourage the flexible reallocation of management resources such as capital and labor by changing working process at the corporate level in accordance with changes in the socio-economic environment and the advent of new technologies, as well as by improving efficiency in the labor and capital markets.

JEL Classification: E20, O30, O47

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1. Introduction

Japan's rapid aging and shrinking population has and will continue to contribute to a decrease in labor input and a slowdown in the economic growth rate. Based on these demographics, in order to encourage Japan's sustainable growth, it is necessary to increase the labor participation rate and labor productivity. In terms of the labor participation rate, it is possible to raise the rate to a certain extent by enhancing incentives for women and seniors to work, but there is a limit to any increase through this method alone. Considering the limitations, labor productivity will play an essential role for medium- to long-term growth in Japan.

This paper summarizes recent discussion on labor productivity and examines the challenges of its sustainable improvement for medium- to long-term growth in Japan based on empirical analysis. Specifically, we analyze several factors which affect the sustainable growth of labor productivity after confirming that labor productivity has an effect on the nation's medium- to long-term economic growth. Based on these factors, we then examine the issues of sustainable growth at the Japanese company level, which leads to issues at the national level.

We touch upon the relationship between the theme of this paper and discussions of "secular stagnation," a phenomenon recently observed in advanced countries. It has become clear that economic growth rates not only in Japan but also in many other advanced countries are on downward trends, and there have been many discussions on the causes of these trends (Chart 1).[1] The series of discussions on secular stagnation can be roughly divided into two streams, by focusing on either the demand-side or supply-side. Summers (2013), providing a representative discussion on the demand-side, insists that traditional monetary policy cannot provide economic stimulus sufficiently facing the zero lower bound on nominal interest rates under the negative natural rate of interest, and thus, as total demand continues to be below total supply, the economy falls into secular stagnation. On the other hand, Gordon (2015), providing a representative discussion on the supply-side, mentions that secular stagnation is caused by the lack of innovative technologies which are the source of the economic growth. These arguments are not exclusive, but rather interact with each other, each exerting a negative influence on the national economy over differing time horizons. Labor productivity, as analyzed in this paper, shows the concept of output efficiency and thus is directly related to

[1] See, for example, Coen and Baldwin (2014) and Nakano and Kato (2017) who summarize the discussions on secular stagnation.

Gordon's supply-side discussion. Meanwhile, the natural rate of interest which plays a vital role for the demand-side discussion, under certain conditions, is the concept that corresponds to a potential growth rate — the growth rate of potential GDP indicating aggregate supply — hence discussions of both demand-side and supply-side are closely tied to each other in the medium to long-run.[2,3] From this perspective, any analysis of changes in labor productivity and the determinants of its movement supplements the series of discussions regarding secular stagnation over recent years.

The rest of the paper proceeds as follows. In Section 2, we observe the trends of labor productivity and related indicators in each country. Section 3 gives an overview of the arguments regarding the global slowdown in the growth rate of labor productivity. In Section 4, we focus on Japan's labor productivity in recent years and examine the background of its sluggishness. Section 5 is the conclusion.

2. Labor Productivity in Major Advanced Countries

Labor productivity provides a measure of the efficiency with which one unit of labor input can produce goods and services and can be measured in various ways.[4] It is calculated by dividing output by total employment (head count), giving 'output per worker,' and is also calculated by the total number of hours worked, giving 'output per hour worked.' Recent growth rates in major advanced countries (Japan, the U.S. Germany) — calculated with either of these measurements — have declined (Chart 2).

From the view point of producers, labor productivity is the measurement of value created by one worker. In order to consider how much value is distributed to an individual person, it is appropriate to use the value calculated by dividing output by total population, output per capita. This gives the 'standard of living per person,' the growth rates of which have declined in major advanced countries in recent years, in the same trend as other labor productivity measures, as mentioned above (Chart 3). This result is obvious since total population and the number of workers move almost proportionally in the long-term.

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2 See Oda and Muranaga (2003) for the relationship between natural rate of interest and potential growth rate.

3 Aoki and Yoshikawa (2002, 2007) point out that demand and supply are closely associated as demand will be in shortfall unless suppliers create new good or service successively, with a reason that demand for an individual good or service eventually faces saturation.

4 Kameda (2009) conducts comprehensive analysis on Japan's productivity developments after the 2000s.

Real GDP expresses the total output of the nation and the growth rate of real GDP can be decomposed into two determinants: labor productivity growth and changes in the number of workers. According to this decomposition, the main reason for the recent decline in growth rates of real GDP in Japan and Germany is the decrease in the growth rate of labor productivity, while the impact of the number of workers are small (Chart 4). The U.S. growth rate of output, in contrast, is affected by both labor productivity and number of workers. While there are slight differences in the background of output fluctuation in each country, this paper focuses on labor productivity which is the common factor in major advanced countries.

The growth accounting framework is useful to analyze factors affecting the growth rate of labor productivity. This growth accounting framework can be expressed with the following simple equation. We assume the following production function in macroeconomics considering capital and labor as production factors.

$$Y_t = A_t K_t^{\alpha} L_t^{1-\alpha} \tag{1}$$

where Y_t, K_t and L_t are output (real GDP), capital input, and labor input, respectively. A_t denotes the efficiency of capital and labor, namely total factor productivity (TFP). α and $1-\alpha$, which express the elasticity of output to capital input and labor input respectively, are known to be equal to the capital share and labor share in the steady state. This is called the "Cobb–Douglas production function," which is the most general formularization of the production function in macroeconomics. This production function expresses that the output of goods and services can be obtained from production activity through the input of capital and labor, and at the same time implies that the TFP captures the efficiency with which labor and capital are combined to generate output. Taking the logarithm of both sides of the equation provides the following relationship:

$$y_t = a_t + \alpha k_t + (1-\alpha) l_t$$

where y_t, a_t, k_t, l_t show the logarithm of Y_t, A_t, K_t, L_t, respectively, the difference of which expresses growth rates. Setting Δ as the difference of each variable, we arrive at Δy_t (output growth rate of Y_t) as follows:

$$\Delta y_t = \Delta a_t + \alpha \Delta k_t + (1-\alpha) \Delta l_t \tag{2}$$

here labor productivity G_t, output per labor input, can be written as follows:

$$G_t = Y_t / L_t$$

Taking the logarithm and differences of the above equation gives

$$\Delta g_t = \Delta y_t - \Delta l_t \quad (3)$$

where g_t is the logarithm of G_t.

Summarizing the relationship of the above equations, we arrive at the growth rate of labor productivity Δg_t, as follows:

$$\Delta g_t = \alpha(\Delta k_t - \Delta l_t) + \Delta a_t \quad (4)$$

here, $(\Delta k_t - \Delta l_t)$ in the first term on right hand side of the above equation indicates growth rate of 'capital input per worker (K_t/L_t),' namely the growth rate of the capital equipment ratio. Δa_t in the second term is the TFP growth rate.

As expressed above, using the growth accounting framework, the growth rate of labor productivity can be decomposed into the growth rate of the capital equipment ratio and of TFP. The capital equipment ratio indicates how much capital stock, such as buildings, machinery, and software, are used for production activity per worker, and an increase in this ratio is called capital deepening. While the capital equipment ratio captures the change in relative relationship between capital and labor inputs that affects labor productivity, the TFP captures the factor to affect output not attributable to the inputs of capital and labor, and as discussed later, can be interpreted as innovation in a broad sense.[5]

While the capital equipment ratio indicates how much capital is accumulated relative to the number of workers, we should bear in mind that average levels of the capital equipment ratio differ across industries. For example, the capital equipment ratio in a capital-intensive industry, such as the steel industry, which needs large-scale production facilities like blast furnaces, tends to be higher than that in the service industry which is labor-intensive. Therefore, it is appropriate to compare industries of differing capital intensity with TFP rather than with labor productivity, as TFP is not affected by the capital equipment ratio.[6] However, in the case of comparing national levels' productivity in advanced countries with similar industrial structures, labor productivity and TFP should generally show the same trend.

[5] TFP based on more general production functions, such as the one including human capital as a production factor, is obviously different from that based on the standard production function. Through this paper, we assume the standard production function because it is difficult to measure intangible capital such as human capital, and to determine how much this affects production.

[6] TFP measured in this paper includes the business cycle component as changes in the utilization rate of production factor and the effect of economies of scale are not taken into account. See Fueki and Kawamoto (2009) for measuring the productivity by controlling business cycle factors.

It is important to note that the growth rate of the capital equipment ratio is affected by TFP growth in the long-run. Theoretically, there is a balanced growth path ($\Delta y_t = \Delta k_t$), where output and capital input grow at the same speed in a steady state. In this steady state, the balanced growth path equation together with equation (2) provides the following equation.

$$(\Delta k_t - \Delta l_t) = \Delta a_t/(1-\alpha) \tag{5}$$

Equation (5) shows that the growth rate of the capital equipment ratio $(\Delta k_t - \Delta l_t)$ depends on TFP growth Δa_t in a steady state. Combining this equation with equation (4) gives the following equation.

$$\Delta g_t = \Delta a_t/(1-\alpha) \tag{6}$$

As shown in the above equation (6), labor productivity growth, Δg_t, is affected by TFP growth, Δa_t, in a steady state. Note that equation (5) and (6) only hold in a steady state and neither will hold in transition processes toward a steady state.

Chart 5 decomposes the growth rate of labor productivity which is actually observed using the growth accounting framework. The chart shows that TFP has contributed to the recent slowdown in labor productivity of major advanced countries although the magnitudes vary by country.[7] In Germany, the capital equipment ratio has impacted on the slowdown in labor productivity as well as TFP growth to a certain extent. As mentioned above, the growth rate of the capital equipment ratio is affected by TFP growth in the long-run, and therefore the recent slowdown of capital equipment ratio in Germany could reflect the deceleration of TFP growth.

To sum up, first, the growth rate of output at a national level can be explained mainly by the growth rate of labor productivity, or the growth rate of the standard of living per capita, while the impact of population factors such as the number of workers, total population, or that of worked hours is relatively small. Second, the growth rate of labor productivity in advanced countries has been declining in the medium- to long-run. Third, stagnation of TFP has affected the recent slowdown in labor productivity in advanced countries.

[7] Measured TFP differs depending on the specifications of production function, and therefore the capital equipment ratio and TFP measured in this paper are subject to a considerable margin of error. See Kameda (2009) for the discussion on the measurement of labor productivity and TFP.

3. The Global Slowdown in Labor Productivity

As mentioned in Section 2, the stagnation of TFP is a main cause of the slowdown in labor productivity in major advanced countries. This section examines the background of the slowdown in the growth rate of TFP focusing on technological progress.

3.1 Has Technological Progress Stopped?

As explained in the framework of growth accounting above, TFP is a factor of output growth neither explained by capital accumulation nor labor input. TFP can be thought of as technological progresses (innovation), which affects economic growth, in a broad sense.[8] Innovation in this paper means not only the introduction of new technologies, such as the invention of the internal combustion engine and electricity, but also business improvements, such as new business models and the introduction of new schemes of business. This section summarizes two discussions on the causes of the recent slowdown in TFP in this broad sense via the technological stagnation hypothesis, as proposed by economist Robert Gordon: Gordon's hypothesis that innovative technology as the source of economic growth is no longer created in any way; and the critical debates arguing against this hypothesis.

The Technological Stagnation Hypothesis

Cowen (2011) argues that the chance for innovation is now depleted, because "we ate all the low-hanging fruit." Gordon (2012, 2016), taking the same position, insists that the lack of innovative technology affecting the entire economy has led to the slowdown in productivity. Long-term productivity growth was at its highest from the end of the 19th to the late 20th century, as production technologies and the living environment changed dramatically as a result of the explosive spread of the internal combustion engine, electricity, and new communication tools. This widespread creation of new technologies triggered the supply system to expand total production. At the same time, demand for new goods and services spread, resulting in the improvement of productivity and the standard of living. However, Gordon concludes that by 2005, the positive impact of the information and communication technology (ICT) revolution (the third industrial revolution), which began in the late 20th century, had almost been exhausted and its contribution to productivity improvement since then has been limited. In addition, he is pessimistic regarding future productivity improvement in the U.S. society citing the Six

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[8] As mentioned before, the growth rate of the capital equipment ratio depends on TFP growth in the long-run.

Headwinds: a decline in educational standards; a decline in labor force population; rising inequality; globalization (outsourcing to emerging nations with lower wages); environmental issues; and household and government deficits.

Critical Debates against the Technological Stagnation Hypothesis

There are various arguments against Gordon's technological stagnation hypothesis. Brynjolfsson and McAfee (2011, 2014) stress that ICT such as computers and the internet are "General Purpose Technology (GPT)," in the same way as electricity and the internal combustion engine, and their benefits extend not only to specific fields and industries but across the entire economy. As Jorgenson (2001) points out, the expansion of ICT investment enhances productivity in all industries, through labor savings and the improvement of working efficiency, as they all use ICT. Fueki and Kawamoto (2009) suggest that this GPT view can be applied to Japan as well as the U.S. as the utilization of ICT has raised Japan's overall TFP growth since 2000 across the entire economy.

Brynjolfsson and McAfee also take an optimistic stance that growth will continue into the future. They argue that the goods and services utilizing ICT such as smartphones and GPS systems are generally easy to combine and tend to lead to new innovations. Schumpeter (1926), in his celebrated book on the effect of corporate activities on economic development, *The Theory of Economic Development (Theorie der wirtschaftlichen Entwicklung)*, argues that improvements occur by changing the combinations of existing technologies and ideas, namely in new combinations. According to these arguments, it is natural to think that innovation is increasingly likely to be created with the improvement of ICT which makes it easier to combine existing technologies.

Taking a look at efforts on the corporate side, a number of companies have strategically increased their expenditure on ICT in order to create new business models. Many companies in the U.S. particularly have appointed a chief information officer (CIO) to develop their ICT strategy (Chart 6). There is also movement to create new products and services utilizing ICT. Purdy and Daugherty (2016) imply that artificial intelligence (AI) would change our way of working, and improve productivity and economic growth. Moreover, it has also been pointed out that the technological progress of ICT leads to the improvement of productivity in the medical and nursing care industries, particularly in the fields of genetic analysis, treatment of intractable diseases, practical skill improvements in regenerative medicine and through the introduction of nursing care robots (e.g. Institute for International Socio-Economic Studies (2012) and

Himoro (2017)). The number of global patent applications — often used as an indicator to measure technology level — is continuously increasing, a fact that seems inconsistent with the technological stagnation hypothesis (Chart 7).

According to these arguments above, we can infer the following: the assertion of Gordon *et al.*, that productivity and economic growth have plateaued due to the limits of innovation being reached, is unduly pessimistic considering that new innovations are generated constantly nowadays in ICT and the medical industries. It cannot be denied that recent upward impact of ICT on economic growth is smaller than that of the industrial revolution, which originated with the invention of the internal combustion engine and electricity during the 18th and 19th centuries. However, technological innovation, mainly in ICT, will likely raise productivity and economic growth in the future, as Brynjolfsson *et al.* claim.

3.2 Do Innovations Fail to Lead to Progress in Productivity?

If technological innovation as a source of economic growth has not come to an end, why has recent labor productivity experienced a slowdown in the major advanced countries? In this section, we examine the possibility that innovation has not necessarily led to the improvement of productivity in an efficient way; in other words, from the perspective of intangible assets and the reallocation of resources, new technologies have been created but not utilized.

The Role of Intangible Assets

Reforming ways of working and organizations of companies is necessary in order to utilize new technologies which are combined with existing technology and ideas. As Gordon points out, the invention of steam power improved productivity in factories significantly. Productivity would have not have been improved, however, if manpower was simply replaced with steam power, because the factory layout was optimized for manual labor. It is said that productivity improved dramatically after the factory layout was changed completely to function together with the mechanical properties of steam power and when workers became accustomed to the new labor environment. This episode shows that, in order to utilize tangible assets such as the steam engine and the production facilities driven by the engine, it is necessary to efficiently combine tangible assets with enhancements in the skill of workers.[9] There are other factors that enable

[9] Allen (2009) points out that a new technology will lead to improvement in productivity only when there is an environment where such a new technology can create economic profit.

the efficient use of tangible assets, such as, (1) the ways of working and the organizations of companies which facilitates the utilization of management resources such as capital and labor; (2) the technical skills of the labor; and (3) ideas and technologies developed by R&D. These are all examples of 'intangible assets.' An intangible asset is an asset that is not physical in nature and includes the following: intellectual property such as patents and trademarks; human capital such as the skill and ability of labor; and corporate property such as business culture and models.[10] Intangible assets enhance corporate performance, as complementing investment into tangible assets such as production facilities and computers as well as labor input, and then an increase in intangible assets leads to an increase in TFP.

Common sense tells us that it takes considerable time to change ways of working drastically through changes in the socio-economic environment or technological innovation. In other words, it takes a long time to accumulate the intangible assets which would contribute to improving productivity. In fact, Brynjolfsson *et al.* show that it took thirty years to reorganize factories in accordance with the Second Industrial Revolution which introduced electric power. While new systems utilizing ICT for inventory control and e-commerce have been developed after the ICT revolution, ICT introduction alone will not improve productivity if companies simply stick to the same way of business prior to its introduction. If recent technological innovation represented by ICT has not improved productivity, it is because factors such as ways of working, the organizations of companies and the skills of the labor have not adapted to the technological innovation sufficiently.

The Role of Resource Reallocation

Another reason that productivity improvement has not been achieved through innovation is that the potential of innovation cannot be fully taken up because of the insufficient reallocation of management resources such as capital and labor. Aggregate TFP should be enhanced by the market entry of companies with high technology or advanced business models, or by the market exit of companies whose productivity declines because of technology obsolescence (e.g. Baily *et al.* (1992) and Forster *et al.* (2001)). However, in the case where there is inadequate reallocation of management resources, the rise in TFP and labor productivity is limited. An inefficient financial intermediation function in the banking sector and financial markets prevents capital flow and new investment. Moreover, labor mobility is hindered in a rigid labor market

[10] Corrado, *et al*. (2005, 2009) present the seminal work on the definition of intangible capital.

and workers are fixed at low productivity companies, thus preventing companies from creating innovative technology and business models for growth.

Furthermore, interest groups who are afraid of the loss of vested rights through intensified competition and changes in the socio-economic environment, namely rent seekers, increase political pressure and as a result, technological innovation leading to productivity increases are limited as the reallocation of resources is prevented. For example, if a regulation preventing the new market entry of companies remains even after the essential roles of the regulation come to end, the reallocation of resources through the turnover of enterprises cannot occur. In any case, innovation cannot improve productivity if certain factors, which limit new efforts of companies and workers, remain in factor markets.

4. Reasons for the Decline in Japan's Productivity

This section focuses on Japan and examines reasons for its decline in productivity based on relevant statistical data and empirical studies. As pointed out in previous sections, slowdown in TFP growth rate is the main reason for the decline in productivity growth in Japan and hence we focus on TFP movements (Chart 5). The previous section demonstrated the following: the importance of innovation for productivity improvement; the importance of changes in ways of working, in organizations of companies and labor skills in parallel with innovation; and the importance of the flexible reallocation of management resources such as capital and labor. Based on these points, how should we evaluate Japan's productivity? Here we examine the productivity of individual firms in addition to that of the macro level as discussed in Section 2 in order to deepen the discussion of Japan's productivity.

4.1 Distribution of Firm's Productivity

First, we measure the productivity of individual firms using data of listed manufacturing companies in OECD countries.[11] Using individual firm data at a micro level allows analysis of the cross-sectional heterogeneity of individual firms, which cannot be examined with the macro level data.[12] Following Andrews *et al*. (2015) and Berlingieri

[11] Note that TFP is used as a concept of productivity, unless otherwise noted (for the calculation details see Appendix). As discussed in Section 2, to compare the productivity between different capital intensity firms it is desirable to evaluate by TFP excluding the effect of capital equipment ratio.

[12] Kameda and Takagawa (2003) also provide an analysis using firm-level data. They compare the company distribution of ROAs in Japan with those in the U.S. using a histogram and conclude that

et al. (2017), we define the companies in OECD countries with the top 5% of productivity, as 'frontier firms'. Frontier firms achieving high productivity from a global standpoint can be viewed as relatively superior firms in terms of their utilization efficiency of capital and labor. This section focuses on the differences between Japanese and the U.S. companies through the comparison of frontier firms.[13]

Taking a look at the average TFP in the sample period, though obvious from their definition, the productivity of frontier firms is the highest, and productivity of Japanese companies is lower than that of the U.S. companies on average (left-hand side of Chart 8).[14] The distribution of firm productivity varies considerably and is flatter for the U.S. (right-hand side of Chart 8). While the share of low productivity companies (left tail of the distribution) in the U.S. is higher than that of Japan, frontier firms or those with similar productivity (right tail of the distribution) are fueling all of the U.S.'s productivity. On the other hand, the tail of Japan's distributions is narrow showing that many companies are concentrated around the average level of productivity. This means that while there are few companies with extremely low productivity, there are also few companies which raise the aggregate productivity.

Second, we focus on time-series variations of average productivity for frontier and other companies in each country. After the productivity of frontier firms increased significantly from 2000 to 2006 compared with the average productivity in advanced countries, it has plateaued since 2007 (left-hand side of Chart 9). With this setting as the frontier firms' benchmark, the deviation of average productivity in each country expanded from this benchmark from 2000 to 2006 (right-hand side of Chart 9). Whereas this productivity disparity between the frontier firms and the U.S. companies has shrunk since 2006, when the productivity of frontier firms began to slowdown, the productivity

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Japanese companies are concentrated around the average profit rate, and Japan's company distribution has a smaller standard deviation and remarkably larger kurtosis. Furthermore, the profit ratios have a shorter tail distribution for deficit, which means there are few companies with significantly bad profitability.

[13] The properties of frontier firms in this paper are as follows: the majority of frontier firms are from the U.S. and followed by the Japanese firms. About seven percent of the total U.S. companies are categorized as frontier firms and so are about four percent of the total Japanese companies. GE (2016) points out that the U.S. and Japanese companies are mainly creating innovations in the world.

By industry, about half of the frontier firms are in the electric appliance industry. Many frontier electric appliance companies are thought to be engaged in further upgrading their efficient production system by, for example, outsourcing some of their production operations. In terms of company size, the sales volume of frontier firms is significantly large compared with those of the total population. The ages of frontier firms are significantly young compared with those of the total population.

[14] In our samples, the average of lnTFP is 0.13 and the standard deviation is 0.94.

disparity between the frontier firms and the Japanese companies has not shrunk. In other words, while the U.S. companies on average have been able to follow frontier firms, Japanese firms have pulled away from the frontier firms and have not be able to close the gap.

Now, we calculate deviations from the frontier firms in terms of productivity in Japan and the U.S. of the following three groups: the top 5%, the middle 90%; and the bottom 5%, respectively (Chart 10). The top 5% companies in both Japan and the U.S. do not greatly deviate from the frontier firms. This means that the top 5% companies in both Japan and the U.S. are mostly included in the frontier firms. Regarding the bottom 5% firms, on the contrary, although both Japanese and the U.S. companies have distance from the frontier firms in common, the distance of the U.S. companies is larger than that of the Japanese companies. This is consistent with the fact that distribution of the U.S. firm productivity has a wider variance and is flatter as we showed in the right-hand side of Chart 8. We see significant differences between Japan and the U.S. across the middle 90% companies. While the productivity of the middle 90% in Japan is close to that of the bottom 5%, it is inversed in the U.S., i.e., the middle is close to the top 5%. The productivity disparity between Japan and the U.S. on average seems to reflect the difference of the middle 90%.

With the above discussion in mind, characteristics regarding Japan's productivity can be summarized as follows. Although some Japanese companies have achieved high productivity from a global standpoint, low productivity companies account for a large percentage as a whole and the nation's productivity at the macro level is left behind the productivity of the U.S. The following sections discuss the cause of low productivity in many Japanese companies in terms of intangible assets and reallocation of resources as introduced in the previous section.

4.2 Japan's Productivity and Intangible Assets

As discussed in Section 3, in order to utilize the technological progress leading to productivity growth, it is necessary to combine accumulated technologies and ideas appropriately mainly through R&D and to change working styles and organizations of companies. This section examines Japan's productivity from the perspective of companies' intangible assets.

It is difficult to measure intangible assets due to considerable constraints on data availability except for some items such as R&D expenditure and software investment. In this section, we try to compare intangible assets in Japan and the U.S. based on the results of Corrado *et al.* (2012) and Fukao *et al.* (2009) in their comprehensive measurements of intangible assets in advanced countries under certain assumptions. Although nominal intangible investment against nominal GDP both in Japan and the U.S. tends to increase, the pace in Japan is significantly lower than that of the U.S. (Chart 11). This result implies that Japan's productivity growth has slowed down because there has not been sufficient investment in software, human and organizational capital, though it is necessary to consider this from a wider perspective due to differences in definition of data regarding industry structure and intangible assets.

Let us turn to the R&D expenditure which is a breakdown item of intangible assets. As Romer (1990) points out, R&D activity is one of the main factors affecting productivity.[15] Taking a look at the ratio of R&D expenditure to nominal GDP, Japan is higher than other advanced countries (Chart 12). An increase in R&D expenditure should encourage the discovery of new technologies or the development of applied technologies and also allow the exploitation of new areas of demand or the enhancement of efficiency in the production process. Therefore, governments often target R&D expenditure to GDP ratio and provide financial support with the understanding that expanding R&D expenditure is important so as to advance a nation's growth (Japan sets the target at least 4%[16], and the U.S. and Europe at 3%[17]). Japan especially has a large share of global patents which can be viewed as the achievement of R&D investment (Chart 13).

Does R&D lead to higher productivity growth? Taking a look at the relationship between TFP and the ratio of R&D expenditure to sales at the individual company level, the more U.S. companies spend on R&D expenditure, the bigger their productivity growth is. However, such an obvious relationship between R&D and productivity growth cannot be observed in Japan (Chart 14), implying that Japan's R&D does not enhance productivity growth. The reasons for this can be thought of as follows: first, although Japanese companies spend a lot on R&D expenditure, this does not necessarily

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[15] R&D expenditure which is a type of intangible asset has been treated as capital stock since the 2008 SNA (System of National Accounts) in the same way as software investment. However, data analyzed in this paper are based on 1993 SNA and are not treated as capital stock.

[16] The Japanese government set the targets in the 5th Science and Technology Basic Plan (FY2016 to FY2020, endorsed by a Cabinet Decision in 2016) as combined public and private sector R&D investment of at least 4% of GDP (government R&D investment of at least 1% of GDP).

[17] The target used here for the U.S. is drawn from President Obama's R&D budget, and the one for Europe is decided by the European Commission (in a survey of the Japan Science and Technology Agency).

lead to the development of products which appropriately meet consumers' needs[18]; second, R&D in Japan tends to be oriented toward gradual improvement rather than creating innovative products (Chart 15); third, Japanese firms adhere to internal R&D, and do not cooperate on technological innovation with other companies and universities as well as do not utilize open source (Chart 16).[19] Regarding the third point, in contrast to firms in other advanced countries, Japanese companies seldom raise funds from abroad or from the government (Chart 17). In addition, technologies and ideas which have not been commercialized are often left to gather dust and are not utilized in other institutions, another reason for the inefficiency of R&D in Japan (Chart 18).

Next, we examine intangible asset in detail; the investment in human capital, which has strong ties to the skill level of labor. Considering the difference in company stances on investment in human capital in Japan, non-manufacturing companies continuously make relatively less investment (Chart 19). Moreover, the ratio of on-the-job training is higher than off-the-job formal training in Japan (Chart 20). It is likely that productivity has not improved due to the insufficient skill accumulation of labor, mainly in nonmanufacturing sector, although this is not always the case as the appropriate training differs according to industry and type of occupation. Furthermore, Kato and Naganuma (2013) point out that the main reasons for stagnation in human capital investments were (1) a reduction in off-the-job training expenditure of firms during the recent recession periods and (2) less internal training opportunities for employees on the premise of simultaneous hiring of new graduates and the life-time employment system, along with a declining trend of the 'regular worker' share especially in manufacturing sector.

4.3 Japan's Productivity and Capital Reallocation

This section discusses the possibility of slowdown in the productivity growth of Japanese companies due to inappropriate reallocation of management resources such as capital and labor. The productivity growth of companies which cannot sufficiently adapt

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[18] For example, Otsuka (2010) adduces an oft-cited reason for Japan's declining R&D efficiency as "Japanese high-function devices, which have developed to stellar standards but in such an idiosyncratic way, are referred to with a touch of mockery as 'Galapagos-ized'. Even though these products may possess competitiveness in the Japanese market, they do not fit the needs of general consumers in overseas markets."

[19] The Japanese government mentions in the report of Basic Concept of Japan Revitalization Strategy 2016, "the keys to realizing the fourth industrial revolution are open innovation and human resources. Under the difficulties of foreseeing future new technologies, it is clear that there is a limit for a company which makes products only by its own technology."

to demand change or cannot guard against skill obsolescence is likely to decline in the medium to long-term. Where the resources in these companies are not appropriately reallocated to companies which can achieve high productivity growth with new technologies and ideas, the result is a decline in the average aggregate productivity. This section focuses on the differences in productivity growth of individual firms and examines the influence of resource reallocation based on Hogen *et al.* (2017).

Analyzing the influence of the entry and exit of publicly listed companies using firm-level data for Japan and the U.S. as well as employing the Dynamic Olley-Pakes decomposition proposed by Melitz and Polanec (2015), Hogen *et al*. (2017) decompose labor productivity into three factors: surviving firms, entrants and exiters (Chart 21). The surviving firms factor is defined as a factor of the productivity change of firms publicly listed before the previous period. While the entry factor is defined as a factor of the productivity change of firms publicly listed in the previous period, and the exit factor as a factor of the productivity change of firms left the market in the current period. This chart shows that labor productivity growth at the macro level, i.e., on the GDP base, can mostly be captured by aggregating the change in productivity of publicly listed individual firms. Although the trends in productivity growth rate in both of Japan and the U.S. are mainly driven by the surviving firm factor, factors of entry and exit also exert a considerable effect on productivity growth at the macro level.[20] Taking a closer look at this chart indicates the following three points.

First, the contribution of entrants to the growth rate of productivity in the U.S. is bigger on the whole than that of Japan. This is caused by the number of new entries in Japan and the U.S. As is widely known, the entry rate of companies in Japan is lower than that of the U.S. (Chart 22). According to the number of publicly listed firms in Japan and the U.S., while firms which have been listed since the 1990s in the U.S. have considerable presence in the market, those from before the 1980s account for the majority in Japan (Chart 23). The fact that there are fewer new entry firms in Japan than abroad can be attributed to the extremely low levels of entrepreneurship and animal spirits, the fear of failure and low status given to successful entrepreneurs (Chart 24).

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[20] Empirical studies show that the contribution of specific large-scale companies to the national's productivity growth is considerable. For example, Lewis (2004) finds that in the second half the 1990s, Wal-Mart accounted for 4% of the productivity jump in the U.S.. Many studies provide analyses that this is because utilization of ICT contributes to productivity improvement (e.g. Doms (2004)). Gabaix (2011) states that the sales of the top 50 firms accounts for 24% of GDP in the U.S.. Canals *et al.* (2007) conduct an analysis and find that the top 10 Japanese firms account for around 30% of total Japanese exports.

One reason behind these negative attitudes may be the fact that little consideration has been given to enhancing entrepreneurial mind and skills in the Japanese education system to date (Chart 25). In addition, financial barriers may form other obstacles to undertaking entrepreneurial activities in Japan. People have limited experience from their education in how to raise the necessary funds for start-ups and there are few experienced entrepreneurs in the Japanese market who can act as role models (Chart 26).

Second, low productivity firms are likely to exit from the U.S. market at an early stage. As shown in Chart 21, exiter firms in the U.S. have a negative contribution, meaning they have a higher productivity with positive values than that of surviving firms.[21] Firms with positive productivity exit from the stock market because it is those firms that tend to become the target of M&A, and they opt for a smooth exit from the stock market before deterioration in sales and profits as well as productivity deteriorating below that of surviving firms. The figures in Chart 27 show survival rates of low productivity firms over time in Japan and the U.S. Accordingly, survival rates of low productivity firms in both countries decreases as time elapses (i.e., they either exit from the market or improve their productivity), especially in the U.S., where it declines quickly. This may be because firms in the U.S. tend to exit from the market or improve business management quickly due to pressure from shareholders such as financial institutions and institutional investors when their productivities are on the decline. On the other hand, in Japan, even though a firm's earnings or productivity may be deteriorating, financial institutions continue to support the business for a time and allow them to remain in the market, and the business conditions of the firm could deteriorate further.

Inactive exit behavior of firms means that capital and labor is fixed in firms with low productivity growth. In this case, aggregate productivity growth slows down in the medium to long-term due to insufficient reallocation of resources into new entrants. In the case of the U.S. as shown in Chart 21, although exiters have a negative impact on labor productivity at the point of exit, there is a positive effect on productivity at the macro level if capital and labor is reallocated from exiters to surviving firms and new entrants with high productivity growth.

[21] In the analysis of Hogen *et al.* (2017), firms which are listed in year *t-1* and exits from the market in year *t*, are calculated by taking the change in their productivity weighted by their sales. Therefore, if firms with positive (negative) productivity exit the market, the factor of exiters is calculated as negative (positive) value, if the sales in year *t* is not zero.

Third, growth rates in the productivity of surviving firms in the U.S. are generally higher than those of Japan, and surviving firms in Japan have had a downward pressure on macro level growth rate of productivity in recent years. The age of surviving firms is generally higher in Japan than that of the U.S., reflecting the inactive entry and exit of firms (Chart 23). Note that productivity growth of new entrants is higher and tends to decline with age (Chart 28). Newly established firms are thought to have new technologies and ideas as a source of productivity improvement, and firms with a longer history are more likely to find it difficult to adjust their ways of working and their organizations to respond to the emergence of new technology and changes in demand. As discussed in the previous sections, this is one of the reasons that Japanese companies cannot utilize intangible assets effectively. It can also be presumed that the contribution of surviving firms to the productivity growth is small in Japan — as firms which would have been exited from the market under the U.S. circumstances and environment — remain as survivors. Aside from this, in a corporate acquisition of a high productivity company, while exit of the target company would contribute to a decrease in aggregate productivity, the productivity of the acquirer (the surviving firm) improves. The difference between the two countries is due to much fewer M&As taking place in Japan than in the U.S. (Chart 29).

As has been discussed, productivity growth of Japanese companies has been sluggish compared to that of U.S. firms; one reason behind this may be that entry and exit are not conducted as smoothly depending on the profitability and productivity of firms, resulting in the inefficient allocation of management resources such as capital and labor. The inactive entry and exit of firms in Japan results in a higher age of surviving firms, which may lead to an acceleration of sluggishness in productivity growth.

It has been pointed out that the German legal framework prompts the entry and exit of firms (Kinoshita (2014)). In Germany, when corporate managers continue to operate firms knowing that the firms have a negative capital position, they can be prosecuted in criminal or civil action. Therefore, firms must be dissolved or acquired by other firms when their corporate managers become aware of the possibility of negative capital and are unable to raise additional capital. Due to this pressure from the legal framework, low productivity firms are forced to exit from market, and capital and labor are reallocated to more productive firms. In addition, the European Commission prompts member countries to amend legislation so that firms facing financial and business difficulties can start to restructure their businesses promptly (European Commission (2014)).

4.4 Labor Market, Financial and Capital Market, and Productivity

Based on the discussion above, the following issues are important to enhance productivity at the macro level in Japan: enabling the ease of entry into the market for firms with potentially high productivity; encouraging firms with low productivity to exit the market and reallocating capital and labor to those with high productivity smoothly; and improving the productivity of surviving firms. Next, we focus on the labor market and financial/capital markets and consider the optimal policy settings and systems to achieve sustainable growth of Japanese companies and the economy.

Labor Market and Productivity

Here we examine the influence of the labor market on productivity. This paper focuses on 'labor market flexibility' which expresses the extent of labor mobility for re-employment via unemployment, and is one of the indexes of labor market's structural conditions.[22] Taking a look at the relationship between labor market flexibility and the growth rate of productivity in OECD countries, there is a tendency that higher rates of productivity growth are observed in the countries with higher labor market flexibility (Chart 30). Whereas both labor market flexibility and the productivity growth rate of the U.S. are high, the situation in Japan is completely opposite, that is, both indexes are low. Based on the relationship of entry and exit discussed in Section 4.3, this can be interpreted as follows. Companies with declining profits and productivity are driven into exit or bankruptcy, and employees of those companies are let go, ending up unemployed. However, when labor market flexibility is sufficiently high, it is possible that these unemployed workers are then employed by high productivity firms or establish their own business. This leads to an improvement of aggregate productivity at the macro level.[23] On the other hand, when labor market flexibility is low, long-term unemployment tends to linger and continues to hurt human capital, and low productivity businesses tend to be operated in such a way as to avoid letting employees go. These factors could slow down productivity in the medium to long-term at the macro-level. Facing a low flexibility in the labor market, a company might be more averse to taking the risk of implementing a new business plan. The company which finds a good

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[22] Labor mobility is measured by the ratio of the sum of flows in and out of short-term unemployment (unemployed less than one month) for population aged 15-64.

[23] It is highly possible that average productivity at the macro-level declines in the case of a shift in industrial structure when employees move from high productivity industries to low productivity industries. Fukao and Kim (2008) analyze Japan's productivity and find that the impact of the shift in industrial structure to TFP is smaller than changes in TFP of individual enterprises and offices. Hsieh and Klenow (2017) also point out the same issue exists in the U.S..

opportunity for a new business may not invest and expand its number of employees because the company fears that it cannot promptly exit from the business even after the business failure is revealed. This could be one reason that the productivity of Japanese companies tends to concentrate around zero (Chart 8).

Case studies of Sweden are often cited when discussing the relationship between labor market and productivity growth. Yamada (2016) explains the importance of enhancing flexibility in the labor market, a key feature of the labor market in that country, by emphasizing that the labor force shifts smoothly from sectors with low productivity to those with high productivity due to income compensation and enhanced vocational training for employees. Letting employees go, on the other hand, is relatively easy for companies, and this point also lead to improve flexibility in the labor market.

It has been said that high productivity of Japanese companies were attributable to several intrinsic factors such as stable labor-management relations, the system of lifetime employment and the seniority-based wage system (e.g. Abegglen (1958) and Koike (1991, 1994)). Recent studies, however, question the effectiveness of lifetime employment and the seniority-based wage system because they may hinder labor mobility, meaning workers do not have a chance to demonstrate their potential productivity (e.g. Yanagawa (2009)). Why has the assessment of these same systems changed over just a few decades? Yamada (2016) concludes that lifetime employment and the seniority-based wage system functioned effectively for the training of human capital, the succession of industry-specific techniques and the development of loyalty to firms during the era of high economic growth. The system worked very well while the population was on the increase and when there was a clear target for the individual standard of living and the technological level of society in the era. However, by the time the era ended and the economy had matured, it was clear that Japanese companies had been forced to set the direction of technological development and the target of technology level by themselves without referring to other countries as a benchmark. Moreover, Japanese companies now have to face the shrinking domestic market as the population declines. It is therefore possible that the well-functioning employment practices and systems of the high growth era have depressed productivity recently.

Aoki *et al*. (2017) examine the reasons for lower productivity in Japan compared to that of the U.S. based on an endogenous growth model focusing on the distance to the U.S. as the world technology frontier. They find that Japan could not switch its path from being a catch-up regime — where companies enhanced productivity by copying the innovative technology of the U.S. firms — to an innovation regime — where companies grow productivity through their own R&D activities — and thus Japan fell into a "low productivity trap" (Chart 31). On that basis, for Japan to return to a growth-maximizing path they advocate for firms to choose an appropriate innovation strategy and for the government to implement structural reforms in order to enhance labor mobility.

Financial/Capital Markets and Productivity

In addition to labor, capital is also an important input factor. As has been discussed, if inefficiency in the financial and capital markets is high, firms with potentially high productivity cannot meet their financial needs and as a result both capital accumulation and TFP are slowed down. Productivity growth at the macro-level will increase if capital reallocation proceeds effectively and the sales share of profitable and productive firms increase.

However, in Japan, it has been pointed out that capital is not always reallocated to high productivity firms or industries smoothly due to a firm's stance or government policy which attempts to restrict employment adjustments and bankruptcies in order to secure job security (e.g. Ohtake (2000)[24]). This could result in the protection of low productivity firms and low productivity could spread across the whole market.

Nakajima *et al.* (2016) point out two mechanisms where the deterioration of the financial intermediation function leads to the stagnation of productivity growth based on the previous studies in recent advanced countries. First, insufficient financial regulation before the Financial Crisis in 2008 and large scale financial accommodation after the Crisis lowered the costs of funding for financial institutions and investors, lowering incentives for the thorough examinations of loans and credits, and as a result hindering credit provisions for productive investments. Second, the deterioration of financial institutions' balance sheet quality after the Crisis caused a decrease in loan provision, leading to a reduction of firms' capital expenditures and the decrease in capital equipment ratios of firms. However, there is no consensus on how much these factors affected productivity growth from a quantitative standpoint.

Nakajima *et al.* (2016) introduce several empirical analyses which illustrate that the deterioration of the financial intermediary function put downward pressure on

[24] Ohtake (2000) points out that if employment adjustment subsidies have tended to be provided to industries facing the highest rates of job loss, namely those structurally depressed industries, the speed of employment adjustment may be slow and appropriate inter-sectorial labor allocation could be also distorted in Japan.

productivity growth due to the accumulation of inefficient capital formation. Levine and Warusawitharana (2014) point out the possibility that productivity growth at the macro-level decreased because severe financial situation caused by the Financial Crisis prevents the implementation of risky projects that may have had the potential to create significant profits. Ferrando and Ruggieri (2015) find that the restrictions on fundraising tend to reduce labor productivity and such tendencies are observed more severely in small and medium sized firms rather than in large firms based on empirical analysis using the euro area data set. Sekine *et al.* (2003) and Caballero *et al.* (2008) examine Japan's financial crisis and point out that one of the reasons for slowdown of productivity growth since 1990s is inefficient capital allocation due to the malfunction of the financial market and financial intermediaries. This is a problem of forbearance lending and zombie firms.

5. Conclusion

This paper summarizes recent discussion on labor productivity as the source of medium- to long-term economic growth and observed the current situation using relevant statistical data. Furthermore, we examined the background of Japan's low labor productivity growth in recent years and analyzed issues for Japan's sustainable growth.

Labor productivity in major advanced countries has decelerated over recent years. Using the growth accounting framework to decompose, we find that this is affected mainly by a slowdown in TFP.

One reason for the slowdown in TFP — which can be thought of as innovation in a broad sense — is explained by the technological stagnation hypothesis which attributes the slowdown to a lack of innovative technology creation as a source of economic growth. However, considering that technological innovation is constantly being generated nowadays in ICT and the medical industries, this may be unduly pessimistic. When it is taken into consideration that technological innovation as a source of economic growth has not petered out, the main reason that it has not led to productivity growth can be attributed to issues related to intangible assets and resource reallocation.

An 'intangible asset' is a general concept which includes ways of working in order to utilize management resources such as capital and labor, the labor force's skills and intellectual property accumulated by R&D. Intangible assets investment is thought to enhance corporate performance and productivity growth by complementing both tangible assets such as production facilities and labor input. In order to lead technological innovation to productivity improvement, intangible assets investment is necessary so that corporate organizations and working processes change flexibly in accordance with the emergence of new technologies. Japan's productivity has recently decelerated because there may not have been sufficient investment in these intangible assets. Moreover, Japanese firms adhere to internal R&D and do not cooperate across companies and this has also contributed to a slowdown in R&D efficiency.

The productivity of companies which cannot sufficiently adapt to the change in demand structure or cannot guard against skill obsolescence is likely to decline in the medium to long-term. If the management resources of these companies are not appropriately reallocated to companies with high productivity growth, the aggregate productivity growth at the macro level declines. A slowdown of productivity growth in Japan is likely to reflect inactive entry and exit of firms, resulting in inefficient reallocation of management resources such as capital and labor.

As has been discussed, in order to enhance Japan's productivity in the medium- to long-term, reallocation of management resources by improving the efficiency of the labor market as well as financial markets should be reinforced, allowing the effective use and accumulation of intangible assets. Note that various systems and business customs in the labor and financial markets as well as in firms are mutually dependent. Aoki (2001) points out the possibility that inefficient systems tend to be robust and long-lasting even under rapid environmental changes if systems and business customs are mutually dependent. In order to improve productivity, we need to change those systems and business customs as a whole in a consistent manner.

References

Abegglen, J. C. (1958), *The Japanese Factory: Aspects of Its Social Organization*, The Free Press.

Allen, R. C. (2009), *The British Industrial Revolution in Global Perspective*, Cambridge University Press.

Andrews, D., C. Criscuolo, and P. N. Gal (2015), "Frontier Firms, Technology Diffusion and Public Policy: Micro Evidence from OECD Countries," OECD Productivity Working Papers, No. 2.

Aoki, K., N. Hara, and M. Koga (2017), "Structural Reforms, Innovation and Economic Growth," Bank of Japan Working Paper Series, No. 17-E-2.

Aoki, M. (2001), *Toward a Comparative Institutional Analysis*, The MIT Press.

Aoki, M. and H. Yoshikawa (2002), "Demand Saturation-Creation and Economic Growth," *Journal of Economic Behavior & Organization*, Vol. 48. pp. 127-154.

——— and ——— (2007), *Reconstructing Macroeconomics: A Perspective from Statistical Physics and combinatorial Stochastic Processes*, Cambridge University Press.

Baily, M., C. Hulten, and D. Campbell (1992), "Productivity Dynamics in Manufacturing Plants," *Brookings Papers: Microeconomics*, 4, pp. 187–267.

Berlingieri, G., P. Blanchenay, and C. Criscuolo (2017), "The great divergence(s)," OECD Science, Technology and Innovation Policy Papers, No. 39.

Brynjolfsson and A. McAfee (2011), *Race Against the Machine*, Digital Frontier Press.

——— and ——— (2014), *The Second Machine Age*, W. W. Norton & Co. Inc.

Caballero, R. J., T. Hoshi, and A. K. Kashyap (2008), "Zombie Lending and Depressed Restructuring in Japan," *American Economic Review*, Vol. 98 (5), pp. 1943-1977.

Canals, C., X. Gabaix, J. M. Vilarrubia, and D. E. Weinstein (2007), "Trade Patterns, Trade Balances and Idiosyncratic Shocks," Columbia University Working Paper.

Coen, T. and R. Baldwin (2014), *Secular Stagnation: Facts, Causes and Cures*, CEPR Press.

Corrado, C., J. Haskel, C. Jona-Lasinio, and M. Iommi (2012), "Intangible Capital and Growth in Advanced Economies: Measurement Methods and Comparative Results," INTAN Investment Working Paper.

———, C. Hulten, and D. Sichel (2005), "Measuring Capital and Technology: An Expanded Framework," NBER chapters, in: *Measuring Capital in the New Economy*, pp. 11-46, National Bureau of Economic Research, Inc.

———, ———, and ——— (2009), "Intangible Capital and US Economic Growth," *The Review of Income and Wealth*, Vol. 55 (3), pp. 661-685.

Cowen, T. (2011), *The Great Stagnation*, Dutton.

Doms, M. (2004), "Productivity Growth and the Retail Sector," FRBSF Economic Letter.

European Commission (2014), "Commission Recommendation of 12.3.2014 on a New Approach to Business Failure and Insolvency."

Fernald, J. (2014), "Productivity and Potential Output before, during, and after the Great Recession," *NBER Macroeconomics Annual*, Vol. 29 (1), pp. 1-51.

Ferrando, A. and A. Ruggieri (2015), "Financial Constraints and Productivity: Evidence from Euro Area Companies," Working Paper Series 1823, European Central Bank.

Foster, L., J. Haltiwanger, and C. Krizan (2001), "Aggregate Productivity Growth: Lessons from Microeconomic Evidence," NBER Chapters, in: New Developments in Productivity Analysis, pp. 303-372

Fueki, T. and T. Kawamoto (2009), "Does Information Technology Raise Japan's Productivity?," *Japan and the World Economy*, Vol. 21 (4), pp. 325-336.

Fukao, K., and Y. Kim (2008), "Productivity, Resource Allocation, and Economic Growth in Japan," Global COE Hi-Stat Discussion Paper Series 014, Hi-Stat, Institute of Economic Research, Hitotsubashi University (available in Japanese only).

——— and H. U. Kwon (2006), "Why Did Japan's TFP Growth Slow Down in the Lost Decade? An Empirical Analysis Based on Firm-Level Data of Manufacturing Firms," *Japanese Economic Review*, Vol. 57 (2), pp. 195-228.

———, T. Miyagawa, K. Mukai, Y. Shinoda, and K. Tonogi (2009), "Intangible Investment in Japan: Measurement and Contribution to Economic Growth," *Review of Income and Wealth*, Vol. 55 (3), pp. 717-736.

Gabaix, X. (2011), "The Granular Origins of Aggregate Fluctuations," *Econometrica*, Vol. 79 (3), pp. 733-772.

GE (2016), *2016 GE Global Innovation Barometer*, GE Reports.

Gordon, R. J. (2012), "Is U.S. Economic Growth Over? Faltering Innovation Confronts the Six Headwinds," NBER Working Papers 18315, National Bureau of Economic Research, Inc.

——— (2015), "Secular Stagnation: A Supply-Side View," *American Economic Review*, Vol. 105 (5), pp. 54-59.

——— (2016), *The Rise and Fall of American Growth*, Princeton University Press.

Himoro, E (2017), "Using and application for ICT in the field of medical, nursing care and health care," Mizuho Information & Research Institution Report, Vol.13 (available in Japanese only).

Hogen, Y., K. Miura, and K. Takahashi (2017), "Large Firm Dynamics and Secular Stagnation: Evidence from Japan and the U.S.," Bank of Japan Working Paper Series, No. 17-E-8.

Hsieh, C. and P. Klenow (2017), "The Reallocation Myth," Economic Policy Symposium - Jackson Hole, Federal Reserve Bank of Kansas City.

Institute for International Socio-Economic Studies (2012), "Research and Study on Further Aging and Smart Aging," Institute for International Socio-Economic Studies (available in Japanese only).

Jorgenson, D. (2001), "Information Technology and the U.S. Economy," *American Economic Review*, Vol. 91 (1), pp. 1-32.

Kameda, S. (2009), "Issues on Japan's Productivity: How Do We Evaluate Productivity Developments Since 2000?" Bank of Japan Working Paper Series, No. 09-J-11 (available in Japanese only).

——— and I. Takagawa (2003), "International Comparison of ROA- Return on capital of Japanese companies," Bank of Japan Working Paper Series, No. 03-11 (available in Japanese only).

Kato, R. and S. Naganuma (2013), "Globalization and Japan's Economy," Bank of Japan Working Paper Series, No. 13-J-13 (available in Japanese only).

Kinoshita, N. (2014), "Environmental Improvement to Enhance the Growth Potential of Japanese Companies - International comparisons and lessons from German structural reforms," Shoken Review (Securities Review), Vol. 54 (8), Japan Securities Research Institute (available in Japanese only), pp. 1-31.

Koike, K. (1991), "Economics of Work," Toyo Keizai (available in Japanese only).

——— (1994), "Benefit and Universality of Japanese Employment System," Toyo Keizai (available in Japanese only).

Levine, O. and M. Warusawitharana (2014), "Finance and Productivity Growth: Firm-Level Evidence," Finance and Economics Discussion Series, No. 2014-17, Federal Reserve Board.

Lewis, W. W. (2004), *The Power of Productivity: Wealth, Poverty, and the Threat to Global Stability*, University of Chicago Press.

Melitz, J. M. and S. Polanec (2015), "Dynamic Olley-Pakes Productivity Decomposition with Entry and Exit," *RAND Journal of Economics*, Vol. 46 (2), pp. 362-375.

Nakajima, J., K. Nishizaki, and M. Hisamitsu (2016), "Slowdown of Labor Productivity in Advanced Countries," BOJ Reports & Research Papers (available in Japanese only).

Nakano, A. and R. Kato (2017), "The Recent Debate on 'Long-Term Stagnation': Focusing on the 'Hysteresis Effect'," Bank of Japan Review, No. 2017-J-2 (available in Japanese only).

Nishimura, K. G., T. Nakajima, and K. Kiyota (2005), "Does the Natural Selection Mechanism Still Work in Severe Recessions? Examination of the Japanese

Economy in the 1990s," *Journal of Economic Behavior & Organization*, Vol. 58 (1), pp. 53-78.

Oda, N. and J. Muranaga (2003), "On the Natural Rate of Interest: Theory and Estimates," Bank of Japan Working Paper Series, No. 03-J-5 (available in Japanese only).

Ohtake, F. (2000), "Time for Turning Point of Employment Stimulation: from Aggregate Demand Control to Structural Policy," *Economics & Policy*, Feature issue on job mobility, Spring edition, Toyo Keizai (available in Japanese only).

Otsuka, T. (2010), "What Causes the Declining Competitiveness of Japanese Companies? - Issues from the Viewpoint of Research and Development," Mizuho Report (available in Japanese only).

Prime Minister of Japan and His Cabinet (2016), "Japan Revitalization Strategy 2016- The fourth industrial revolution," Prime Minister of Japan and His Cabinet.

Purdy, M. and P. Daugherty (2016), "Why Artificial Intelligence is the Future of Growth," Accenture.

Romer, P. M. (1990), "Endogenous Technological Change," *Journal of political Economy*, Vol. 98 (5), pp. 71-102.

Schumpeter, J. A. (1926), *Theorie der wirtschaftlichen Entwicklung, 2*.

Sekine, T., K. Kobayashi, and Y. Saita (2003), "Forbearance Lending: The Case of Japanese Firms," Monetary and Economic Studies, Vol. 22 (1), Institute for Monetary and Economic Studies, Bank of Japan, pp. 129-156.

Summers, L. H. (2013), *Remarks at the IMF Fourteenth Annual Research Conference in Honor of Stanley Fischer*, Washington DC.

Yamada, H. (2016), *Job Mobility without Unemployment - New Labor Market Reforms for Growth*, Keio University Press (available in Japanese only).

Yanagawa, N. (2009), "Abandoning the Illusion of Lifetime Employment: Towards a System of Employment Tailored to Changes in the Industrial Structure," NIRA, (available in Japanese only).

Appendix: Calculation Method for TFP of Each Company

- Countries: Belgium, Germany, Denmark, Estonia, Finland, France, Greece, Italy, Japan, the U.S.
- Companies: About 2,900 per year (Manufacturing)
- Sample period: CY1998 - 2009[25]
- Data Source: Thomson Reuters, "Data Stream"; OECD, "STAN database"; IMF, "World Economic Outlook"; Cabinet Office, National Accounts of Japan.
- Calculation method[26]:

$$ln\, TFP_{i,t}$$

$$= \left(\ln Y_{i,t} - \overline{\ln Y_t}\right) - \frac{1}{2}\left(SL_{j,t} + \overline{SL_t}\right)\left(\ln L_{i,t} - \overline{\ln L_t}\right) - \frac{1}{2}\left(SK_{j,t} + \overline{SK_t}\right)\left(\ln K_{i,t} - \overline{\ln K_t}\right)$$

$$+ \left(\overline{\ln Y_t} - \overline{\ln Y_T}\right) - \frac{1}{2}\left(\overline{SL_t} + \overline{SL_T}\right)\left(\overline{\ln L_t} - \overline{\ln L_T}\right) - \frac{1}{2}\left(\overline{SK_t} + \overline{SK_T}\right)\left(\overline{\ln K_t} - \overline{\ln K_T}\right)$$

where *T, j, i* shows the base year (CY2000), industry, and companies, respectively and all values are based on PPP. The upper-bars in the equation indicate the average of all samples in each year. The following factors are deflated using the industry-level data classified with the industry classification benchmark (icb).

Y (Net Sales): deflated using GDP deflators by industry

K (Tangible Fixed Capital): deflated using investment deflator by industry

L (Man-hours): Number of employees × Labor hours per person by industry

SL (Cost share of labor): employee income by industry / GDP

SK (Cost share of capital): 1- *SL*

- The definition of frontier firms[27]: upper 5% companies out of all samples in estimated TFP in each year.

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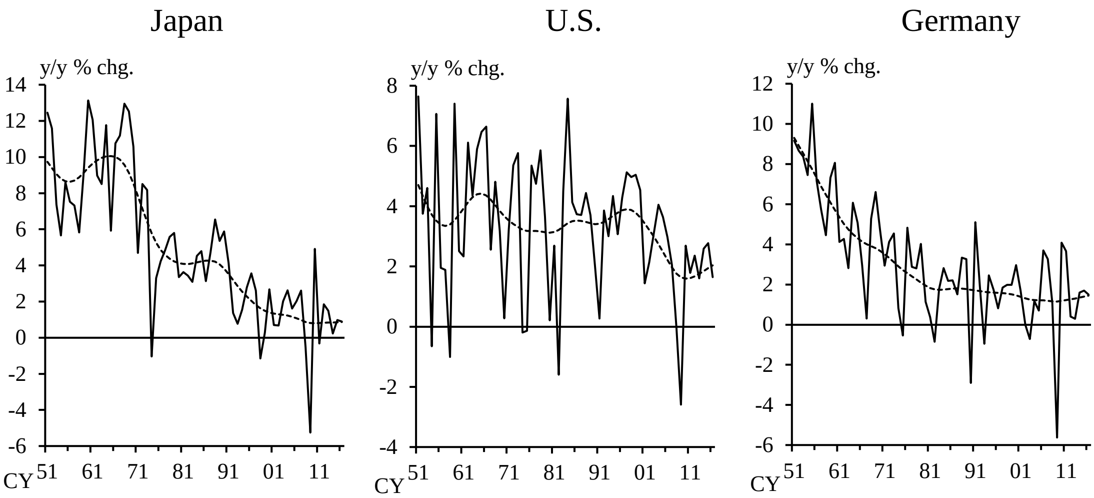
[25] Due to data constraints, the sample period is until CY2009.

[26] Fukao *et al.* (2006) and Nishimura *et al.* (2005) also use the same methodology to calculate corporate TFP.

[27] Andrews *et al*. (2015) analyze productivity of OECD firms and they define frontier firms as top five or top ten percent of the sample, or top 100 companies.

Chart 1. Real GDP

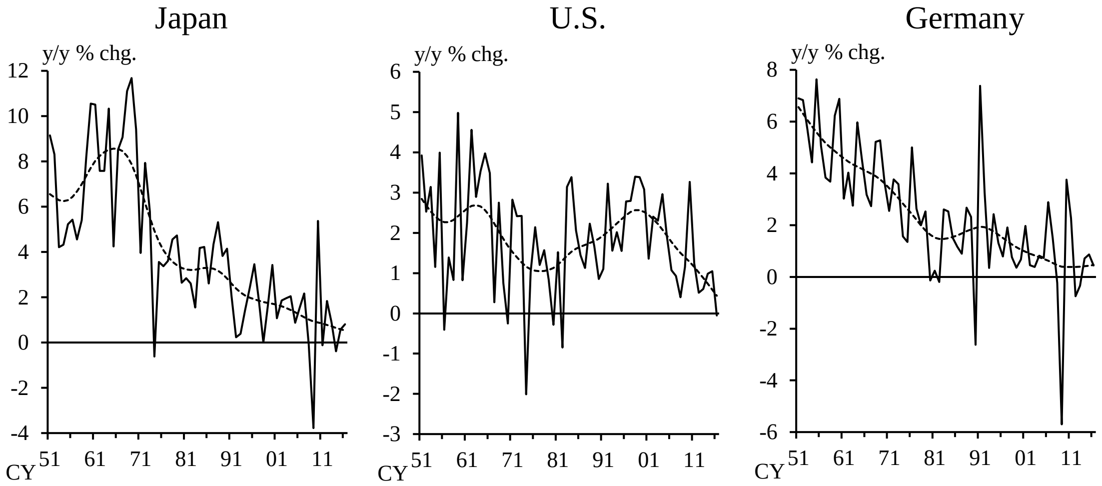


Note: Dotted lines are trends extracted by the HP filter.

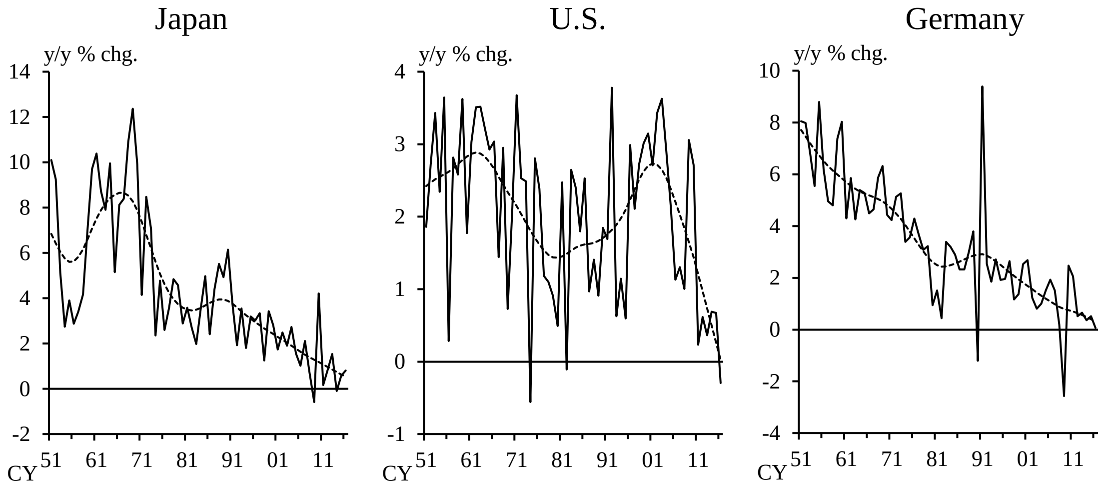
Source: Conference Board.

Chart 2. Labor Productivity

(1) Output per worker



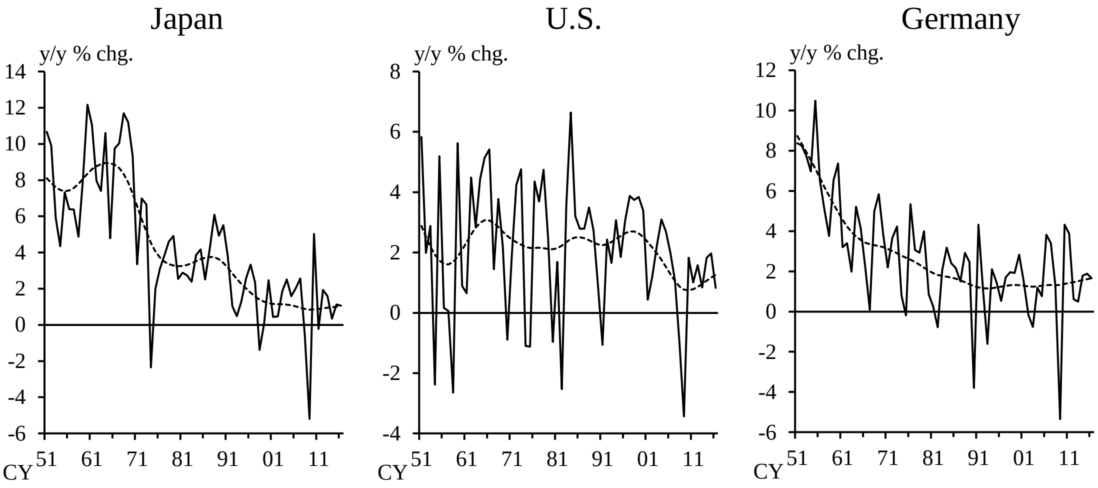
(2) Output per hour worked



Note: Dotted lines are trends extracted by the HP filter.

Source: Conference Board.

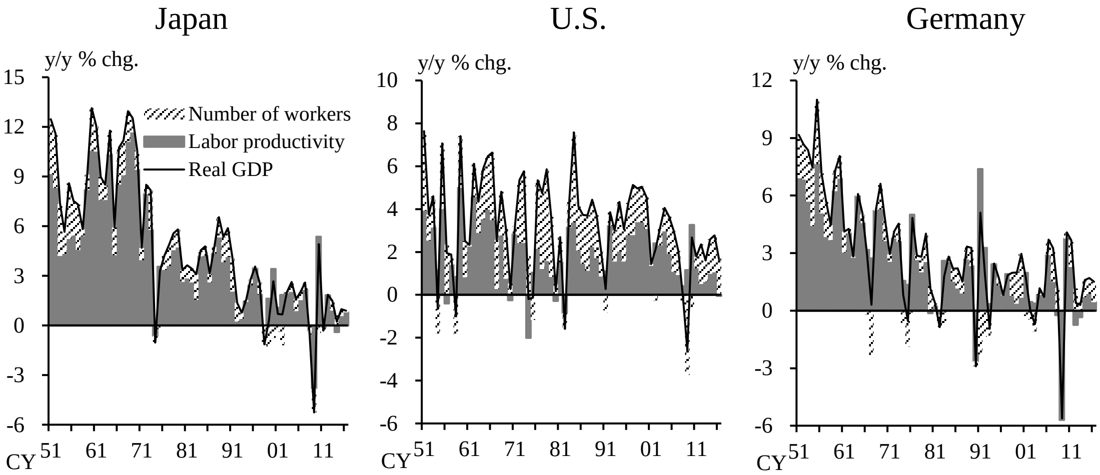
Chart 3. Output Per Capita



Note: Dotted lines are trends extracted by the HP filter.

Source: Conference Board.

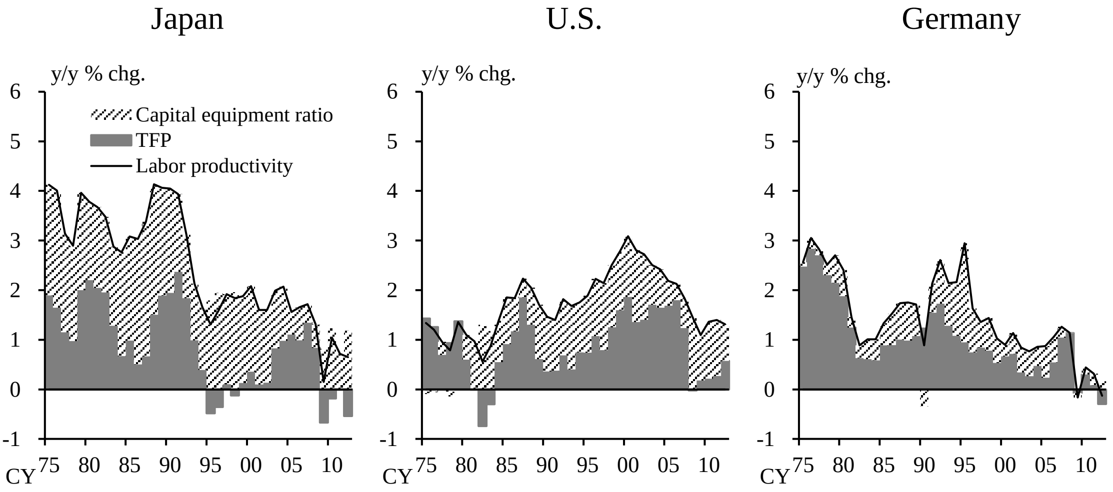
Chart 4. Decomposition of Real GDP



Note: Figures are decompositions of real GDP (Y) into labor productivity (Y/L) and number of workers (L). Figures for labor productivity are the growth rate of the output per worker estimated by Conference Board. Figures for the number of workers are computed by subtracting labor productivity from real GDP.

Source: Conference Board.

Chart 5. Decomposition of Labor Productivity



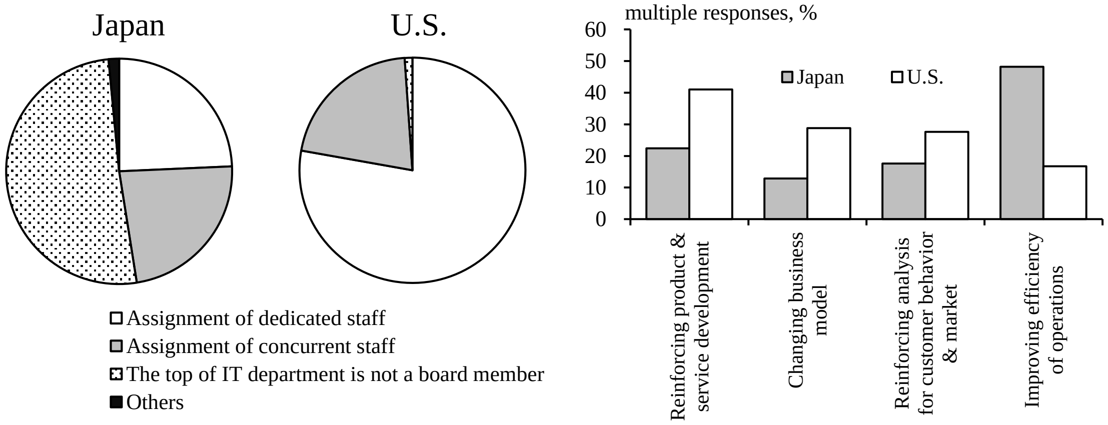
Note: Figures are 5-year backward moving averages. Figures for labor productivity are the growth rate of the output per worker estimated by Conference Board. TFPs in U.S., Japan and Germany are calculated by Fernald (2014), RIETI, EU KLEMS, respectively. Figures for capital equipment ratio are computed by subtracting TFP from labor productivity.

Sources: Conference Board, RIETI, Fernald (2014), EU KLEMS.

Chart 6. Corporate IT Strategy

Assignment of CIO (chief information officer) position

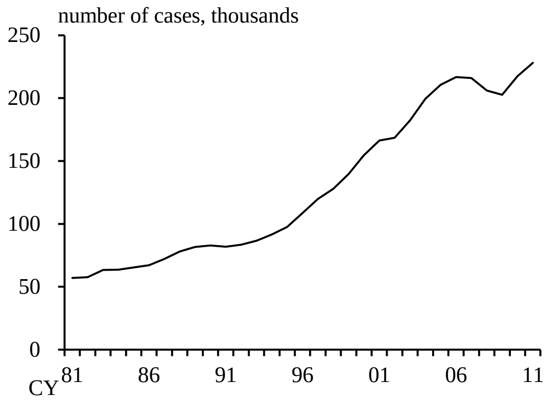
Uses of the IT budget



Note: In 2013 survey. The chart on the right-hand side shows the increase of uses of the IT budget in firms which raise the IT budget (the items extracted are those which had relatively many responses).

Source: JEITA "Comparative Analysis of IT Management between Japanese and U.S. Firms."

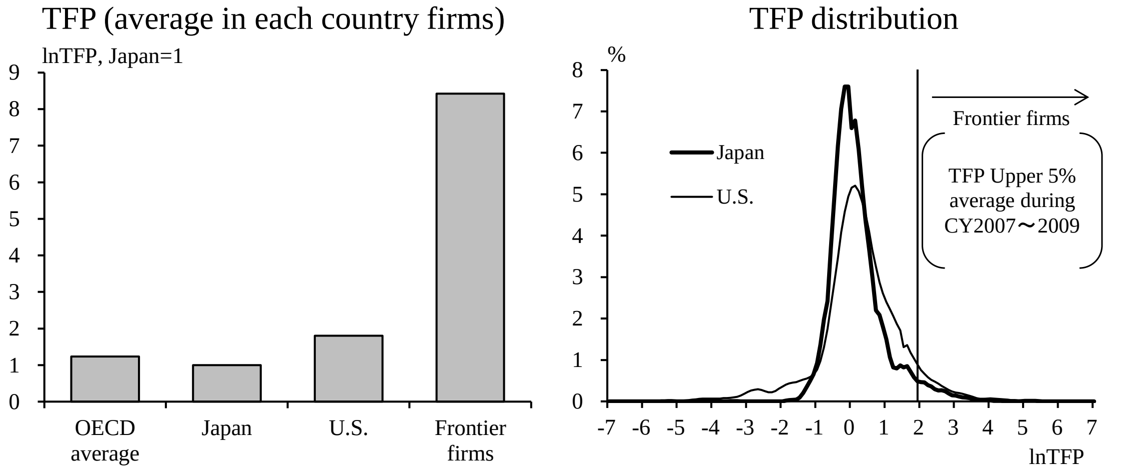
Chart 7. Global Patent Applications



Note: Figures are the aggregated number of patent families from the Ministry of Education, Culture, Sports, Science and Technology (when the same patent is applied to multiple countries, duplications are removed). For the calculation method, see the source below.

Source: National Institute of Science and Technology Policy "Japanese Science and Technology Indicators 2016" (although the digest version of the paper in English is available, the data for this chart is available in Japanese only).

Chart 8. Listed Companies' TFP



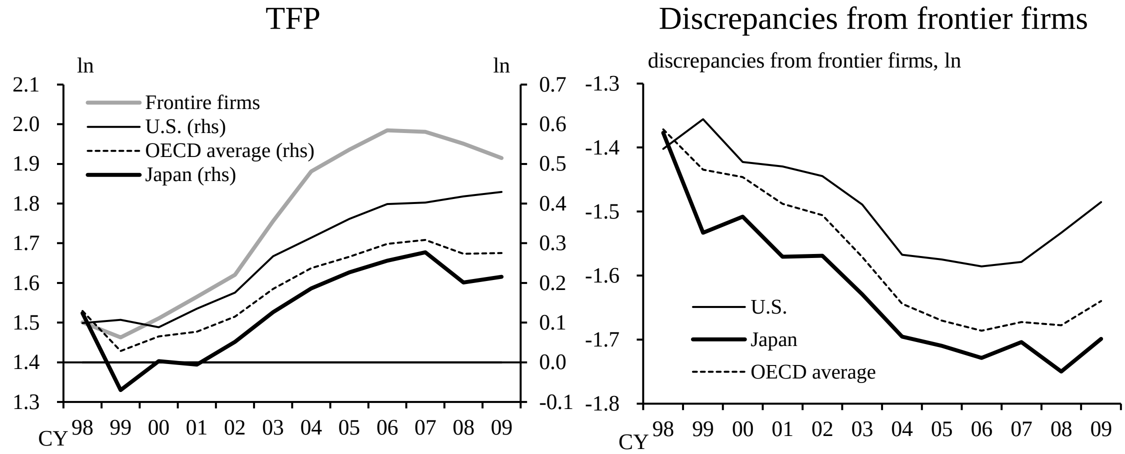
Notes: 1. Each of the listed manufacturing company TFPs in OECD are estimated. The upper 5% of all sample firms are defined as 'frontier firms' and the figure of 'frontier firms' on the left-hand side shows the 5th percentile value (hereinafter the same). For details of the calculation methods, see Appendix.

2. Figures are as from 2007 to 2009.

3. Japanese, U.S. and OECD TFPs in the left chart are calculated by taking the average of firms' TFP weighted by sales. The right chart is calculated with Kernel density estimation.

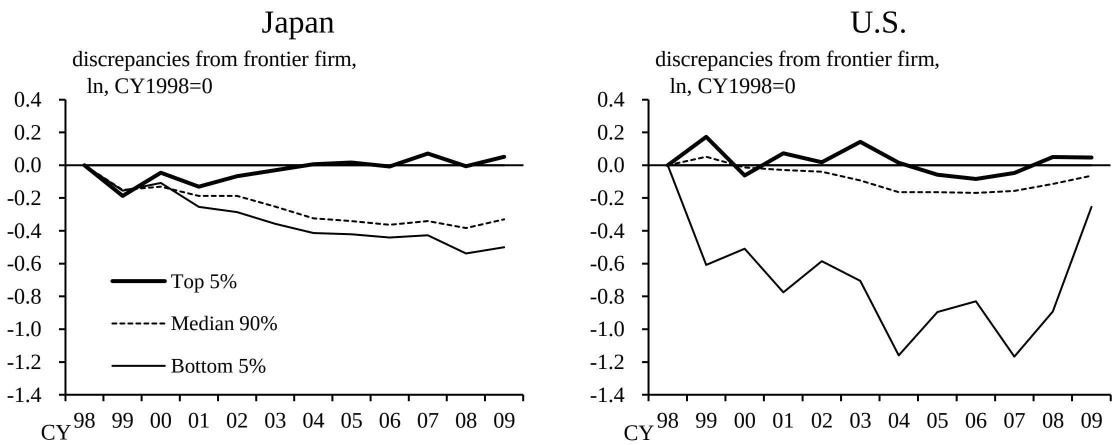
Sources: Cabinet Office "National Accounts of Japan," Thomson Reuters "Datastream," OECD "STAN database," IMF "World Economic Outlook."

Chart 9. Listed Companies' TFP



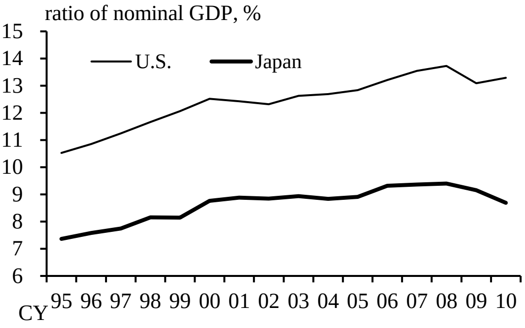
Note: Figures are for manufacturing companies. For each definition, source and calculation method, see the notes of Chart 8 and Appendix. The graph on the right-hand side shows distances between frontier firms and the average in each country firms.

Chart 10. Listed Companies' TFP Classified into Top, Median, Bottom



Note: Figures are for manufacturing companies. For each definition, source and calculation method, see the notes in Chart 8 and Appendix. Figures in the left graph are calculated by taking the average of TFP classified into 3 groups (Top 5%, Median 90%, Bottom 5%) weighted by sales. Figures in the right graph (U.S. firms) are calculated in the same way as Japan.

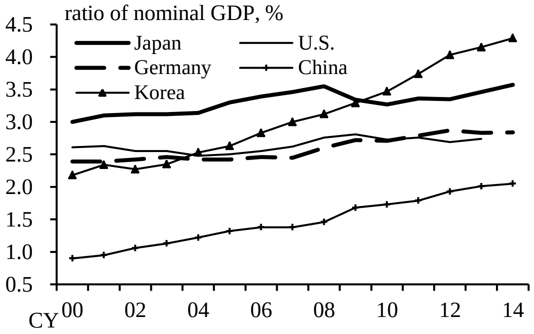
Chart 11. Investment in Intangible Capital



Note: Figures for Japan are measured by the JIP database. Figures for U.S. are sum of the data of INTAN-invest (market sector) and SPINTAN (public sector).

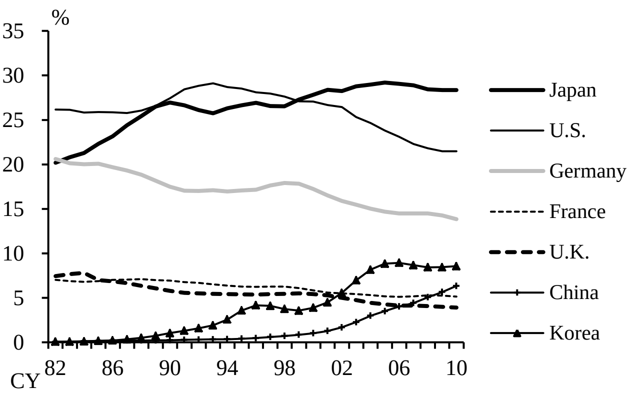
Sources: JIP, INTAN-invest, SPINTAN, IMF.

Chart 12. Research and Development (R&D) Expenses



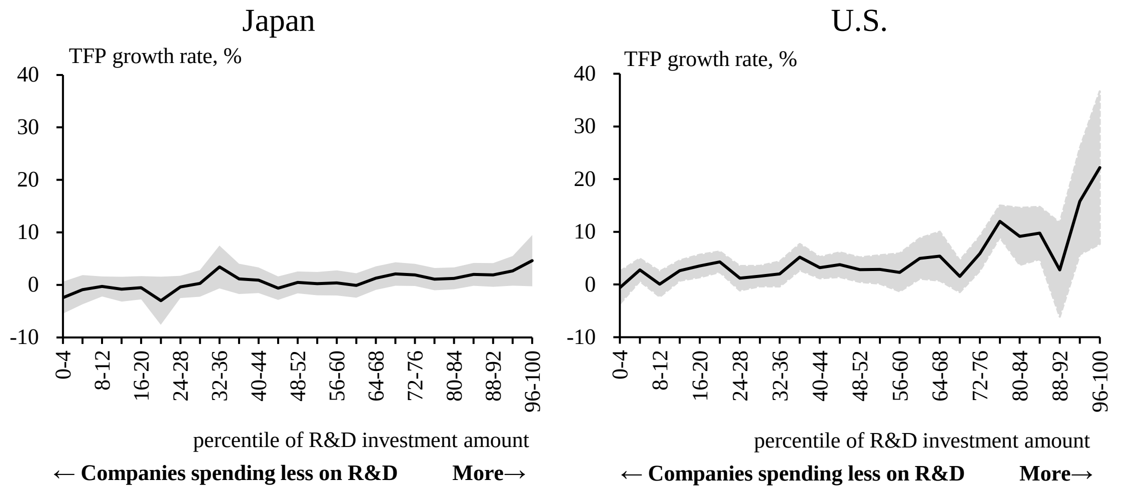
Source: OECD "OECD Main Science and Technology Indicators."

Chart 13. Share in Patent Application of Selected Countries



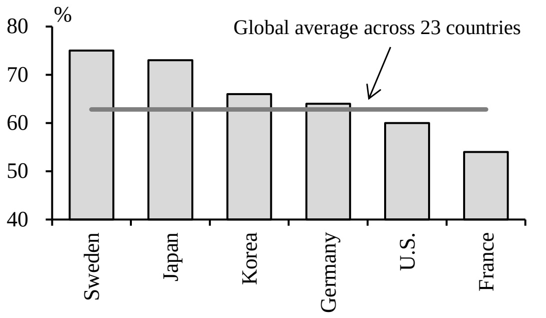
Note: For sources and the calculation methods, see the note in Chart 7.

Chart 14. R&D and Productivity



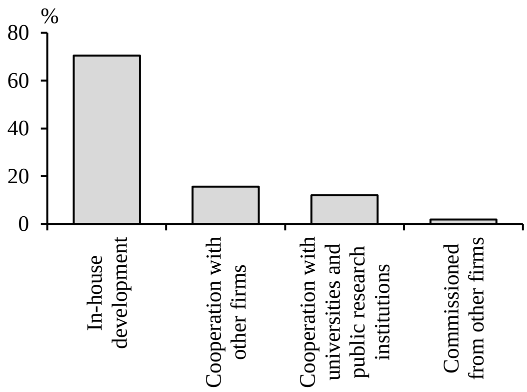
Notes: 1. Figures are for manufacturing companies. For definitions, sources and calculation method, see the notes in Chart 8.
2. The TFP growth rate leads 3- to 5-year ahead (R&D investment (R&D/ Sales ratio) lags behind). The solid line represents its average and the shaded area indicates ±1 standard error.

Chart 15. Preference for Incremental Innovation



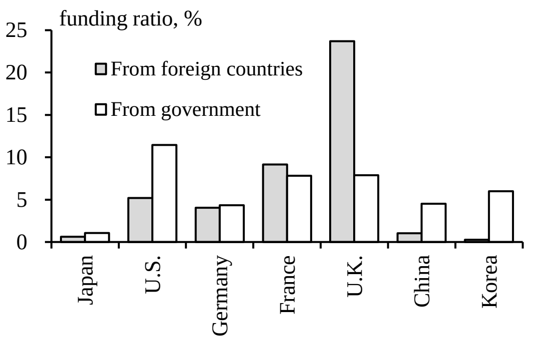
Note: Survey for business executives. Figures show the ratio of companies which prefer incremental innovation rather than breakthrough innovation.
Source: GE "2016 GE Global Innovation Barometer."

Chart 16. Methods for R&D



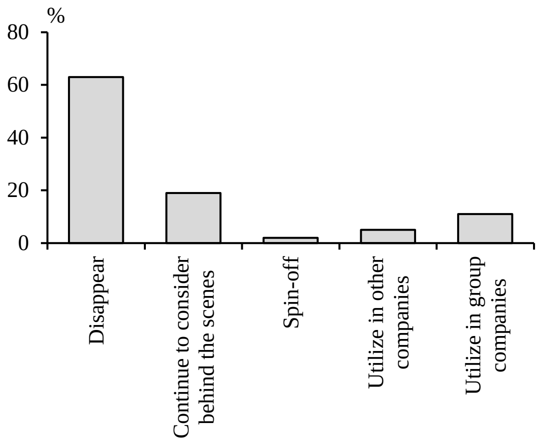
Note: Survey for Japanese companies.
Source: Japan Open Innovation Council "White paper on Open Innovation."

Chart 17. Source of Funds for R&D Expenditure



Note: The main source of funds other than those in the above chart is in-house funding.
Source: Ministry of Education, Culture, Sports, Science and Technology "Indicators of Science and Technology 2015."

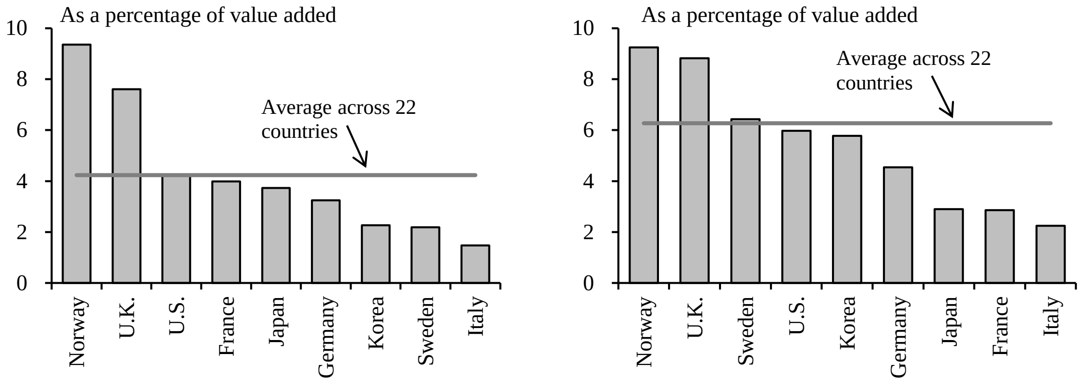
Chart 18. Uncommercialized Technologies



Note: Survey for Japanese companies. The chart shows treatments of technologies and ideas for new business after they had decided not to commercialize in-house.
Source: Japan Open Innovation Council "White paper on Open Innovation."

Chart 19. Human Capital Investment by Industry

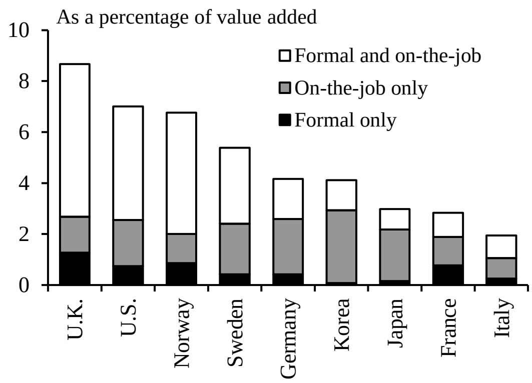
Manufacturing | Non-Manufacturing



Note: Figures are from 2011 to 2012. Selected countries.

Source: OECD "OECD Science, Technology and Industry Scoreboard 2015."

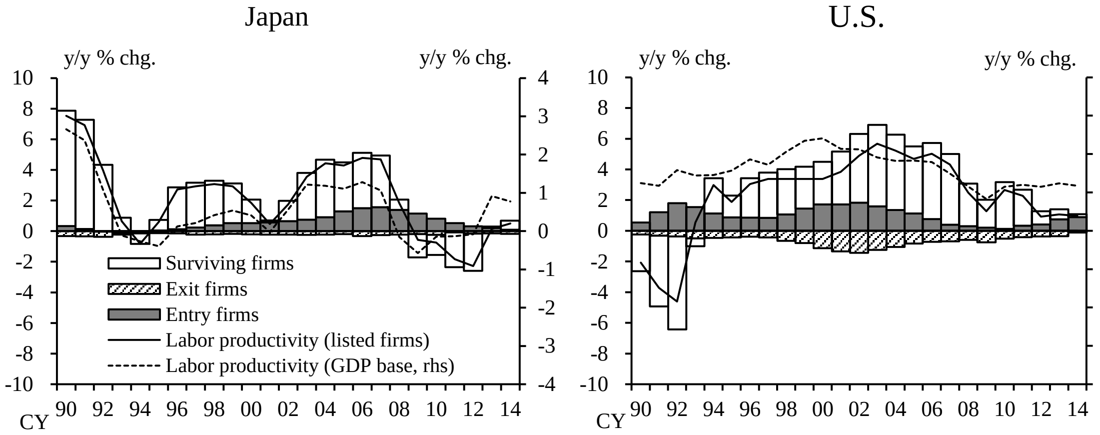
Chart 20. Human Capital Investment by Type



Note: Figures are from 2011 to 2012. Selected countries.

Source: OECD "OECD Science, Technology and Industry Scoreboard 2015."

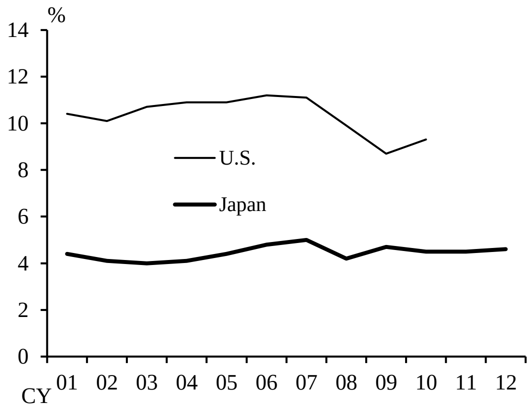
Chart 21. Decomposition of Labor Productivity



Note: Figures are 5-year backward moving averages.

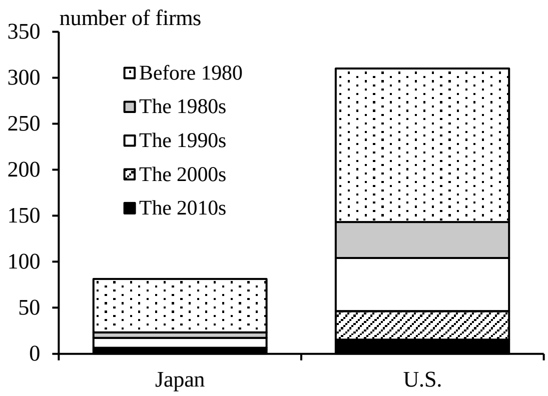
Source: Created on the basis of Hogen *et al.* (2017).

Chart 22. Entry Rates



Source: The Small and Medium-sized Enterprise Agency, "2014 White Paper on Small and Medium Enterprises in Japan."

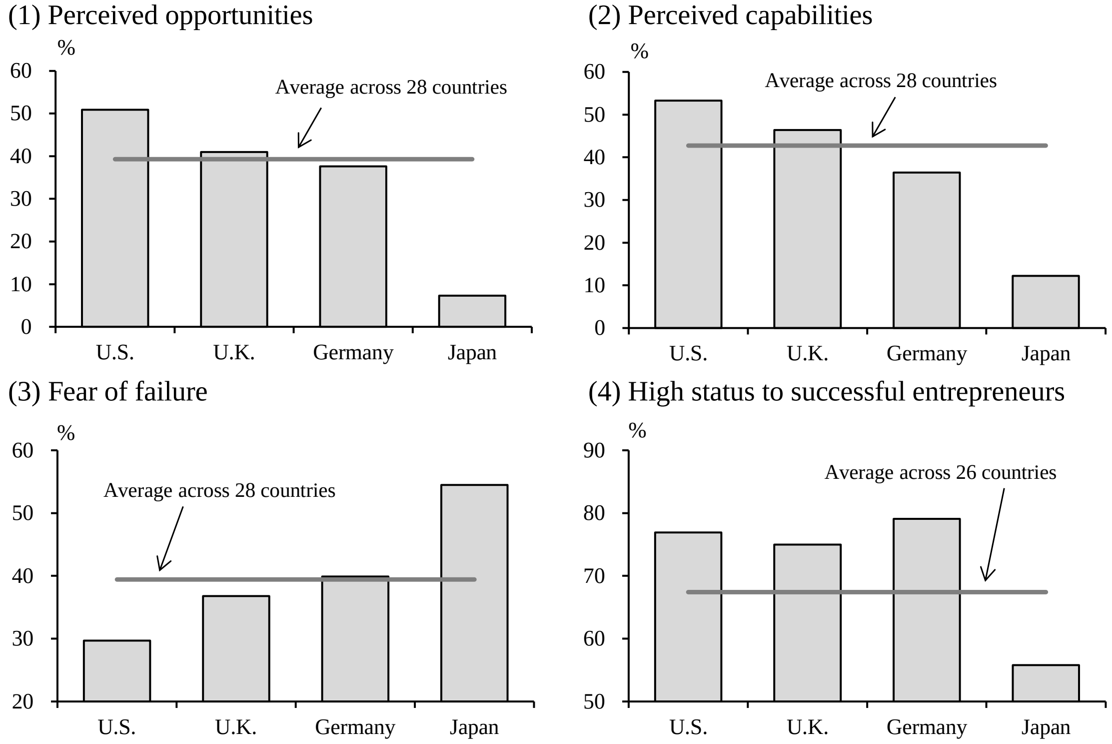
Chart 23. Listed Year of Large Firms



Note: Figures are calculated by summing up the number of companies, whose market capitalizations are more than 10 billion US dollars (as of February 2016 and excluding Financial sector), by the IPO timing. Nationalities are based on headquarters.

Source: Bloomberg.

Chart 24. Animal Spirits

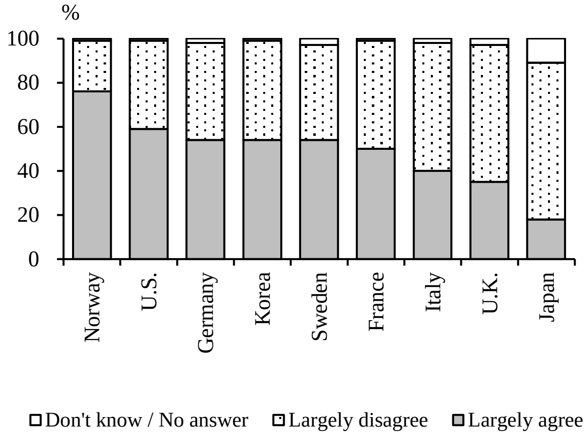


Notes: 1. Survey for individual attributes of potential entrepreneurs in 2014.

2. Perceived opportunities reflects the percentage of individuals who believe there is an opportunity to start a venture in the next six months in their immediate environment. Perceived capabilities reflects the percentage of individuals who believe they have the required skills, knowledge and experience to start a new venture. The measure of fear of failure (when it comes to starting own venture) only applies to those who perceive opportunities.

Source: Global Entrepreneurship Monitor "2014 Global Report."

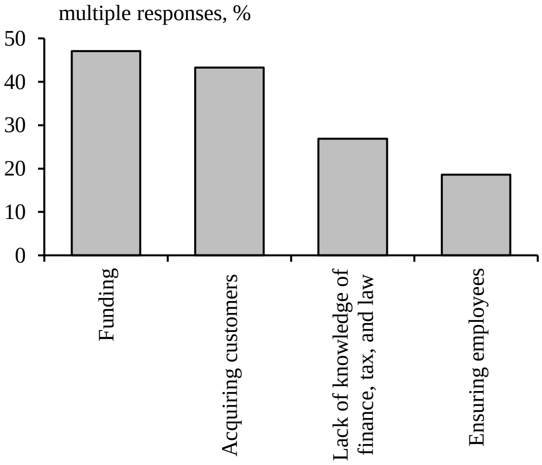
Chart 25. School Helped to Develop a Sense of Initiative and Entrepreneurial Attitude



Note: Figures are as of 2012 and in selected countries.

Source: OECD "Entrepreneurship at a Glance 2013."

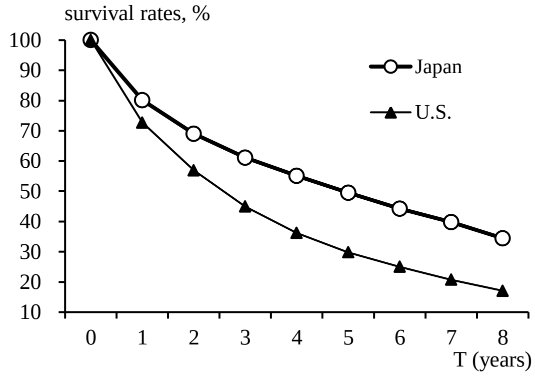
Chart 26. Obstacles at Entry in Japan



Note: Survey for companies which have already started their business.

Source: Japan Finance Corporation "2015 Survey on Business Startups in Japan."

Chart 27. Survival Rates of Low Productivity Firms

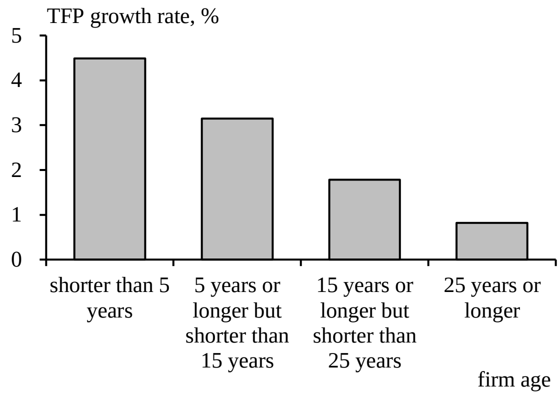


Note: Figures are calculated as follows by using TFPs of individual listed manufacturing firms in Japan (1998 - 2009). For source and calculation methods of firms' TFPs, see the note in Chart 8 and Appendix.

Survival rates of low productivity firms

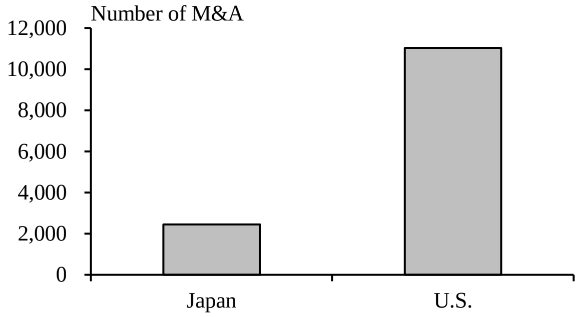
$$= \frac{\text{number of low productivity firms (under 20 percentile from T = 0 to T = t)}}{\text{number of low productivity firms (under 20 percentile at T = 0)}} \cdot 100$$

Chart 28. Firm Age and Productivity



Note: Figures are calculated by using TFPs of individual listed manufacturing companies in Japan and the U.S. (1998 - 2009). For source and calculation methods, see the note in Chart 8 and Appendix.

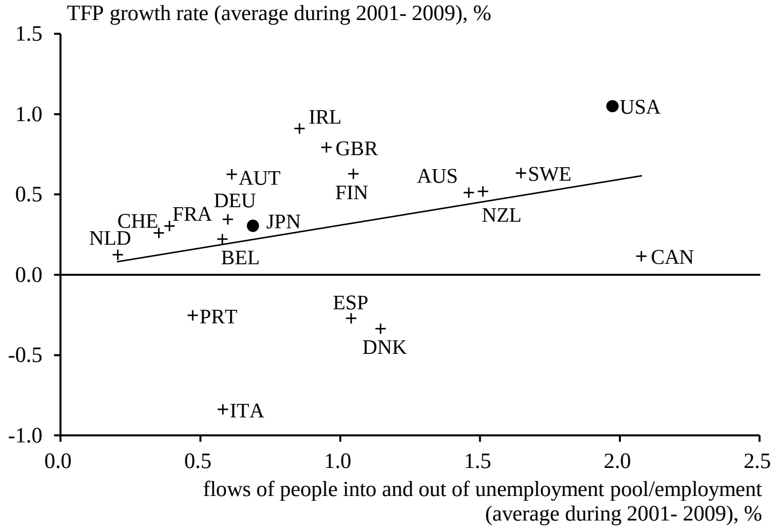
Chart 29. M&A



Note: Figures are as of 2016 and based on public announcement.

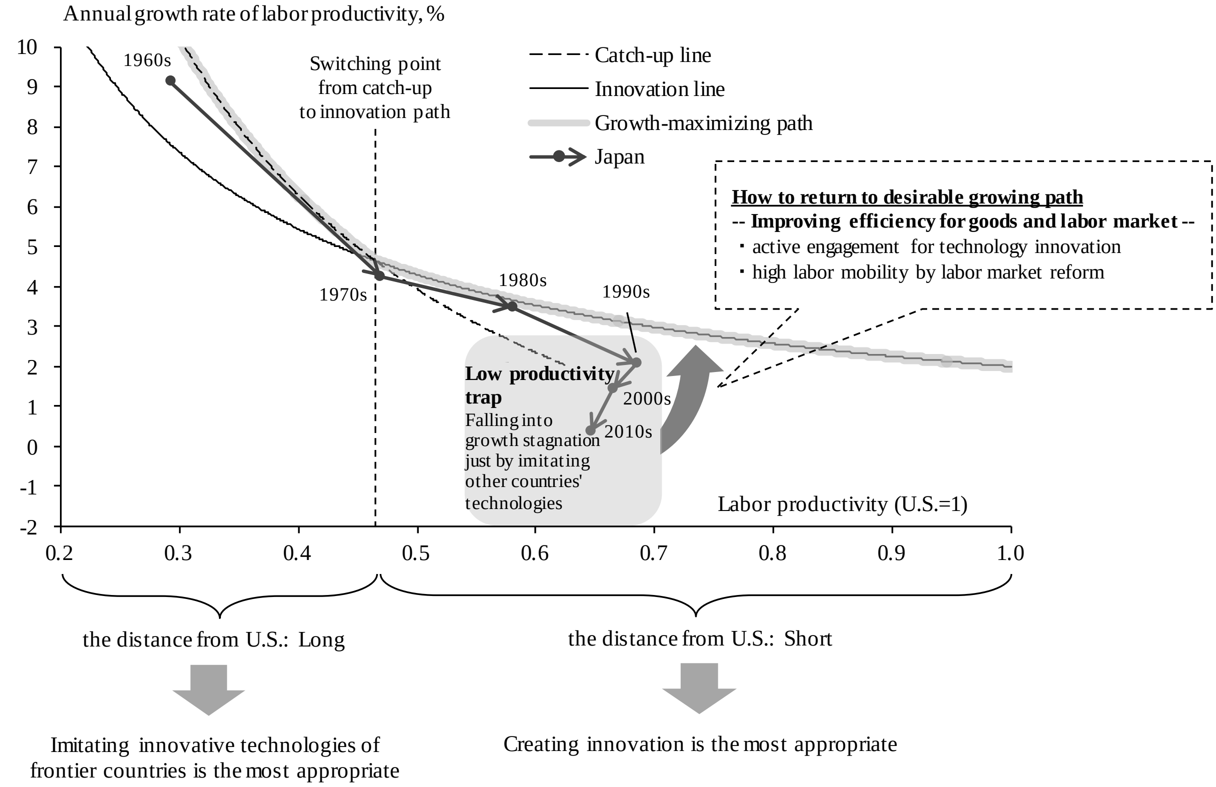
Source: Thomson Reuters "Mergers & acquisitions review."

Chart 30. Labor Market and Productivity



Source: OECD "OECD. Stat."

Chart 31. Growth Path



Source: Created on the basis of Aoki *et al.* (2017).