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Effects of Demographic Changes on Medium- to Long-Term Business Fixed Investment

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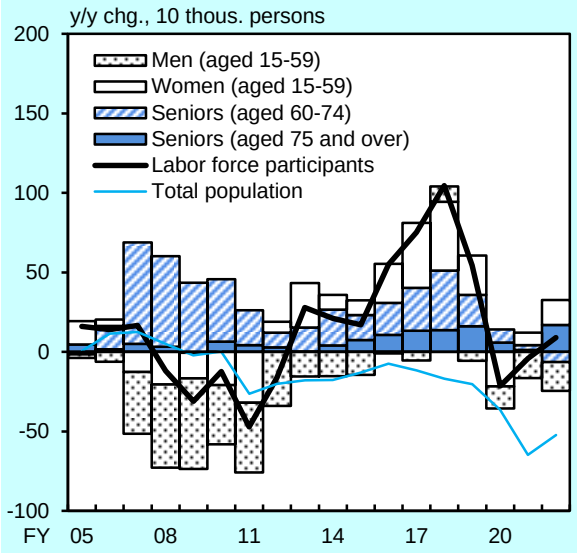
In Japan, labor input is unlikely to increase significantly, based on the outlook for demographic changes. This paper analyzes effects of demographic changes on firms' fixed investment using microdata from the *Tankan*. The analysis shows that firms facing labor shortages tend to be active in making business fixed investment and replace labor with capital (machines). Given that labor market conditions are highly likely to remain tight, potential demand for labor-saving investment to address labor shortages appears to be large. For potential demand to materialize as actual investment, the following factors would be important: firms' medium- to long-term growth expectations being held up; training up highly skilled personnel with sufficient skills to develop and use labor-saving software; and human capital being allocated appropriately through increased mobility in the labor market.

Introduction

In the 2010s, labor supply (the number of labor force participants) increased in Japan even amid a decreasing total population, as labor force participation of seniors and women advanced, with growing labor demand due to economic recovery (Chart 1). However, room for additional labor supply of seniors and women appears to be declining, and labor input is unlikely to increase significantly, based on the outlook for demographic changes.[1]

[Chart 1] Labor Force Participants



Source: Ministry of Internal Affairs and Communications.
Note: Figures for labor force participants are staff estimates adjusted for gaps due to revisions of the benchmark population.

Such decline in labor input would exert downward pressure on Japan's economy. Assuming the standard Cobb-Douglas production function, Y_t, which shows output (real GDP), can be written as:

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

A_t, K_t, and L_t denote productivity, capital input, and labor input, respectively. α represents the capital share and $1-\alpha$ represents the labor share. The subscript t denotes time. Converting this equation into a logarithm shows that the difference from the prior period is the rate of growth, and thereby the GDP growth rate (Δy_t) can be expressed as:

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

In the right-hand side of the equation, Δa_t is productivity growth, $(\Delta k_t - \Delta l_t)$ is growth in the capital equipment ratio (the rate of change in the amount of capital input per unit of labor input), and Δl_t is growth in labor input.[2]

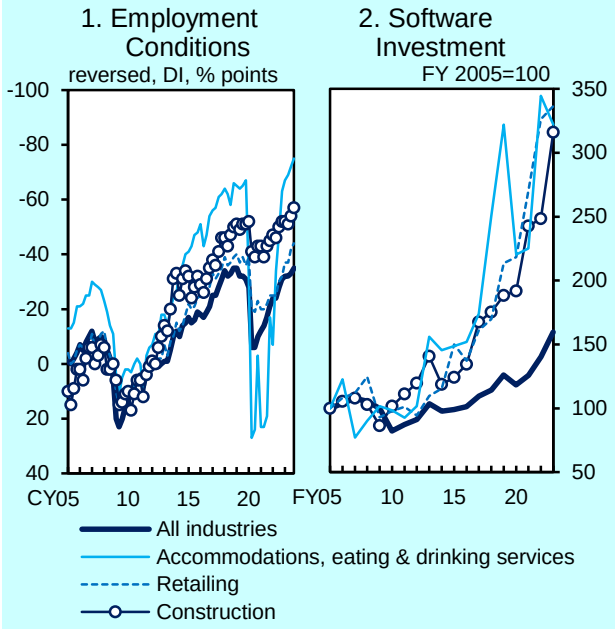
Therefore, for an economy to grow amid declining labor input, it is important that productivity rise or the capital equipment ratio increase, from a somewhat long-term perspective.[3] The importance of productivity for economic growth has been discussed in many studies.[4] This paper examines how tightening labor market conditions will affect firms' medium- to long-term fixed investment stance, in relation to the capital equipment ratio, referring to an analysis using

microdata from the Bank of Japan's *Tankan* (Short-Term Economic Survey of Enterprises in Japan). It then discusses issues involved in achieving economic growth through increasing investment amid the declining population.

Will Labor Shortages Promote Labor-Saving Investment?

We examine whether tightening labor market conditions can promote labor-saving investment as a substitute for labor force. Labor-saving investment followed an uptrend in the economic recovery phase before the pandemic. [5] Although demand for investment declined temporarily after the outbreak of COVID-19, firms' efforts to address labor shortages using digital technology have accelerated recently in labor-intensive industries such as "accommodations, eating and drinking services" and "retailing," which have faced severe labor shortages (Chart 2).

[Chart 2] Industries with Labor Shortages and Software Investment

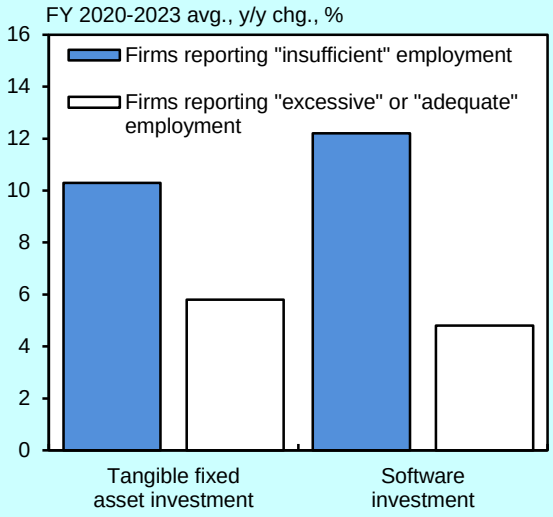


Source: Bank of Japan.

Note: Based on the *Tankan*. All enterprises. The figures for software investment for fiscal 2023 are forecasts from the June 2023 survey.

We use microdata from the *Tankan* in analyzing the relationship between labor shortages and business fixed investment to gain a detailed picture of firms' behavior. First, based on firms' assessment of their employment level in the *Tankan*, we simply categorize firms into two groups: those facing labor shortages (reporting "insufficient" employment), and those not facing labor shortages, and then aggregate the amount of business fixed investment for each group. The results show that firms facing labor shortages have been taking a more active stance toward investment in both tangible fixed assets and software than those not facing labor shortages (Chart 3).

[Chart 3] Investment Depending on Firms' Assessment of Labor Shortages



Source: Bank of Japan.

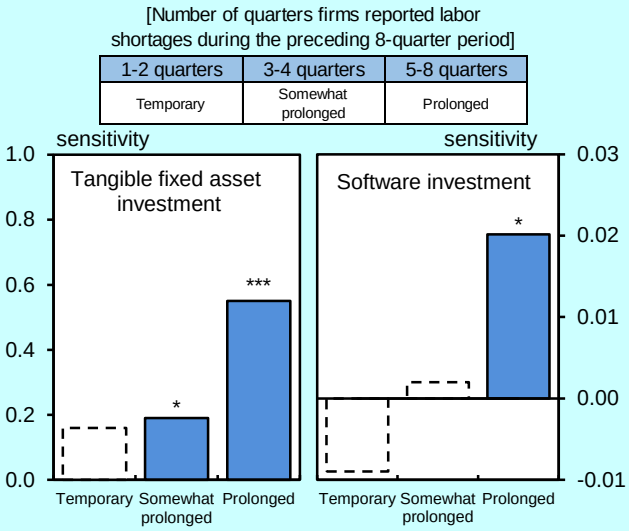
Note: Based on the *Tankan*. All industries and enterprises. The chart shows tangible fixed asset investment (excluding land purchasing expenses) and software investment aggregated based on firms' assessment of their employment level at the beginning of the fiscal year using microdata from the *Tankan*. The figures for fiscal 2023 are forecasts from the June 2023 survey.

Second, we measure the impact of labor shortages on investment depending on their degree, by controlling business cycle components and other factors, including business sentiment and firms' perception of excess production capacity. Specifically, we count the number of times a firm reported "insufficient" employment in the *Tankan* during the preceding eight quarters, and measure whether its stance toward fixed investment differs according to the degree of labor shortages. Smaller numbers indicate that firms have been facing temporary labor shortages, while larger numbers indicate chronic labor shortages. We employ the degree of labor shortages and other factors as explanatory variables and the ratio of business fixed investment to sales as the dependent variable. The results show that firms do not become active in making tangible fixed asset investment immediately when labor shortages are only temporary; however, when labor shortages become acute and prolonged, firms increase such investment in a non-linear manner (Chart 4). Likewise, firms tend to increase software investment when they face persistent labor shortages.

Given these results, since labor market conditions are highly likely to remain tight going forward, it can be said that firms' potential demand for labor-saving

investment is large. However, the extent and pace at which such potential demand will materialize depend on factors such as the following: whether labor can be replaced with capital (machines) in the first place, and whether firms' appetite for investment is maintained (whether their growth expectations are sustained and improved). In the next sections, we examine the current situation in Japan regarding these points.

[Chart 4] Labor Shortages and Business Fixed Investment



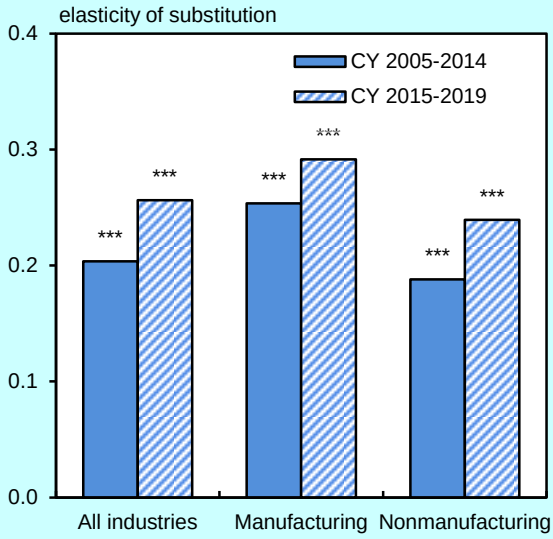
Source: Bank of Japan.

Note: Based on the *Tankan*. All industries and enterprises. The chart shows the sensitivity of the investment to each dummy variable. The dependent variables are the ratios of tangible fixed asset investment (excluding land purchasing expenses) and software investment to sales. Explanatory variables are as follows: dummy variables for the number of quarters firms reported that they had "insufficient" employment during the preceding two-year period as well as firms' assessment of their business conditions, production capacity, and financial positions. The estimation period is from fiscal 2008 to 2022. *** and * indicate that the results are statistically significant at the 1 and 10 percent levels, respectively, while the broken line indicates that the result is not statistically significant.

Can Labor be Replaced with Capital (Machines)?

The elasticity of substitution between labor and capital shows the extent to which changes in the relative price of labor and capital reflecting factors such as wage increases could lead to substitution of capital for labor.[6] An estimation using industry-level panel data shows that the elasticity of substitution in Japan has increased somewhat since the middle of the 2010s, as labor market conditions have tightened, suggesting that firms' efforts to make up for labor shortages with capital have been spreading (Chart 5).[7] While this trend has been seen in both manufacturing and nonmanufacturing, the elasticity of substitution in nonmanufacturing, which had been low, has shown a somewhat considerable improvement. For example, self-service cash registers have been introduced in retailing and an automated check-in system has been introduced in accommodation services, as labor market conditions have tightened and labor shortages have materialized in recent years; such progress has likely led to an increase in the elasticity of substitution in nonmanufacturing.

[Chart 5] Elasticity of Substitution between Labor and Capital



Source: Cabinet Office.

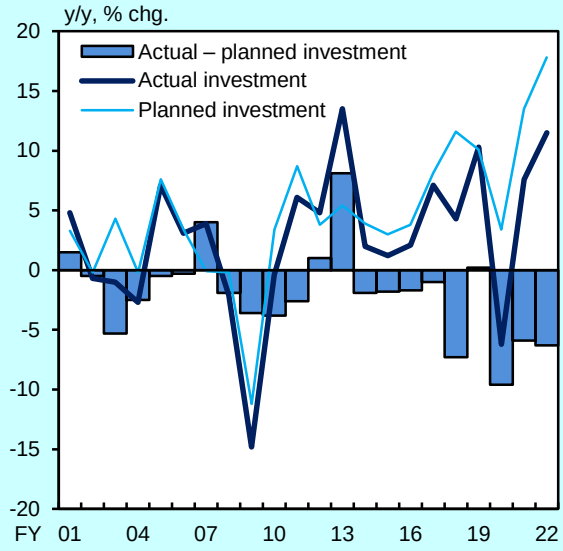
Note: Figures are estimated from the capital intensity and the relative price of capital to labor using industry-level panel data (all industries: 16 industries; manufacturing: 7 industries; nonmanufacturing: 9 industries). The legend shows the estimation periods. *** denotes statistical significance at the 1 percent level.

However, the elasticity of substitution in Japan obtained in our estimation is only in the range of about 0.2 to 0.3, although it has been rising somewhat in recent years. Previous studies that estimated the elasticity of substitution in Japan show similar results, although their number is limited.[8] On the other hand, the elasticity of substitution for the United States obtained in many previous studies is around 1 -- although the results differ across studies -- indicating that the elasticity for Japan is lower compared with the United States.[9]

As explained, the elasticity of substitution has been lower in Japan than in the United States, and firms' efforts toward making labor-saving investment that utilize digital technology have lagged behind, even amid declining software prices due to progress in IT. This may be attributable to firms' cautious investment stance amid continued low growth on the demand side and a lack of highly skilled personnel who can use labor-saving software and machines on the supply side.[10] Paradoxically, highly skilled personnel with sufficient skills to develop and use labor-saving

software and machines is said to be necessary to replace labor with machines.[11] In other words, while labor-saving investment replaces simple labor, it requires highly skilled personnel; therefore, the keys to increasing investment are whether such personnel can be supplied and whether human capital will be allocated appropriately (e.g., reallocated to the sectors that are in need of highly skilled personnel). On this point, it appears that, although the number of job openings for highly skilled personnel has been on an uptrend, they are not being filled due to labor shortages.[12] Given that firms' actual software investment in the *Tankan* recently has been falling far short of their plans as a trend, it is possible that firms have been unable to make as much progress with digitalization as they had planned mainly due to labor shortages (Chart 6).

[Chart 6] Planned and Actual Software Investment

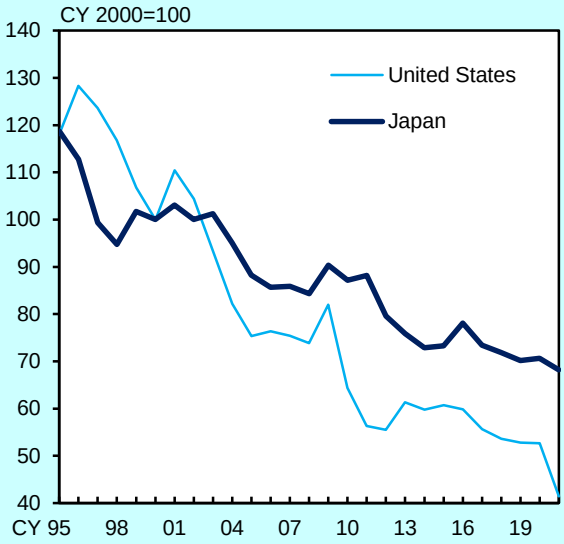


Source: Bank of Japan.

Note: Based on the *Tankan*. All industries and enterprises. Figures for planned investment are those at the time of the December survey of each year.

In addition, a limited decline in the relative price of capital to labor compared with the United States seems to have led to a delay in labor-saving investment in Japan (Chart 7).[13] In the United States, prices of capital such as software have been on a declining trend and wages have continued to rise, and thus the relative price of capital have declined clearly.[14] In contrast, wages had remained at around 0 percent in Japan since the 2000s, in a situation where people's mindset and behavior based on the assumption that wages and prices would not increase easily had been entrenched in society. Consequently, a decline in the relative price of capital to labor in Japan had been limited compared to the United States, and the substitution of labor for capital through this channel had therefore been relatively difficult. In fact, first and foremost, the ICT capital equipment ratio has been at a lower level in Japan compared to the United States and other countries, and its recent growth has also been quite modest; this suggests that the accumulation of capital, such as software, for labor saving has not progressed sufficiently (Chart 8).

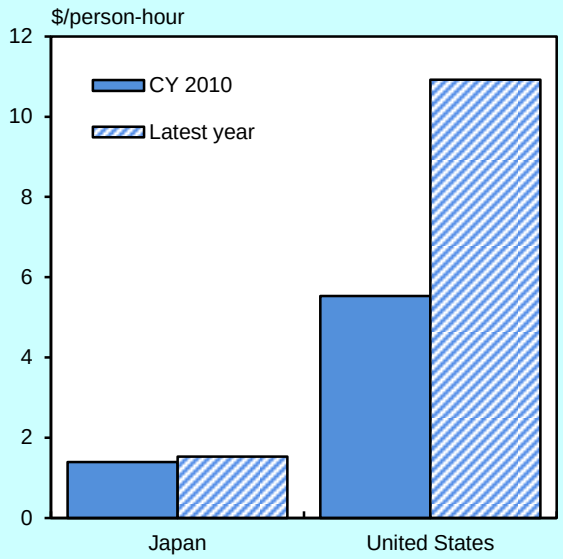
[Chart 7] Relative Prices of Capital to Labor



Sources: Cabinet Office; Ministry of Health, Labour and Welfare; Japan Bond Trading Co., Ltd.; BEA; FRED.

Note: Relative prices are capital rental costs divided by hourly wages.

[Chart 8] ICT Capital Intensity



Sources: EU KLEMS; OECD.

Note: ICT capital is the sum of ICT equipment and software. The latest year is 2018 for Japan and 2020 for the United States.

Such situation in Japan may be interpreted as having large room for growth in labor-saving investment. If the development of highly skilled

personnel will progress through increased investment in human capital and reskilling, areas that can be replaced with capital are expected to grow. In addition, the labor market for regular employees in search of new jobs has expanded in recent years, and it warrants attention on whether the reallocation of human capital will progress through increased mobility in the labor market.[15] As a result, a decline in the relative price of capital to labor due to wage increases is expected to stimulate demand for investment, leading to economic growth.

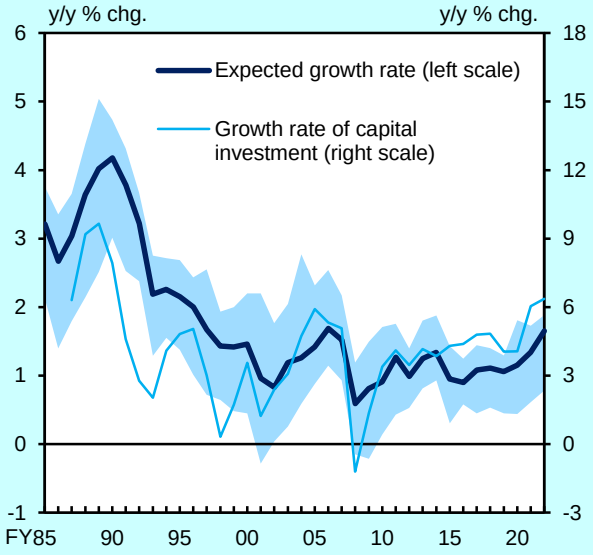
Are Firms' Medium- to Long-Term Growth Expectations Maintained?

Even amid firms' active labor-saving investment, if they think that demand will decline in the future due to the decreasing population, firms' growth expectations will also decline; this will push down capital stock required in a country as a whole, and may lead to firms holding back investment.[16] Therefore, firms' growth expectations are the key in considering overall developments in business fixed investment.

On this point, according to the *Annual Survey of Corporate Behavior* released by the Cabinet Office -- targeting large firms (listed firms) -- the growth rate of industry demand, which is considered to reflect firms' growth expectations, has followed an improving trend (Chart 9).[17] The distribution of individual firms' growth expectations obtained from compiling the questionnaire information (microdata) of the survey shows that a decreasing number of firms have had pessimistic outlook such as continued negative growth, suggesting that growth expectations of many firms have been rising (Chart 10).

It is not easy to identify reasons why growth expectations have been improving amid the declining population. That said, there is a channel through which labor-saving investment driven by intensifying labor shortages has led to an improvement in corporate profits and it is considered to have been mitigating the impact of the declining population somewhat. In fact, a calculation using microdata from the *Tankan* shows that firms actively investing in labor-saving software have been using capital more efficiently (Chart 11). In addition, firms have been active in making investment in view of the next generation including investment in digital transformation and to address environmental issues, and this has likely led to the improvement in their growth expectations.[18] Through these developments, a virtuous cycle from income to spending is expected to intensify.

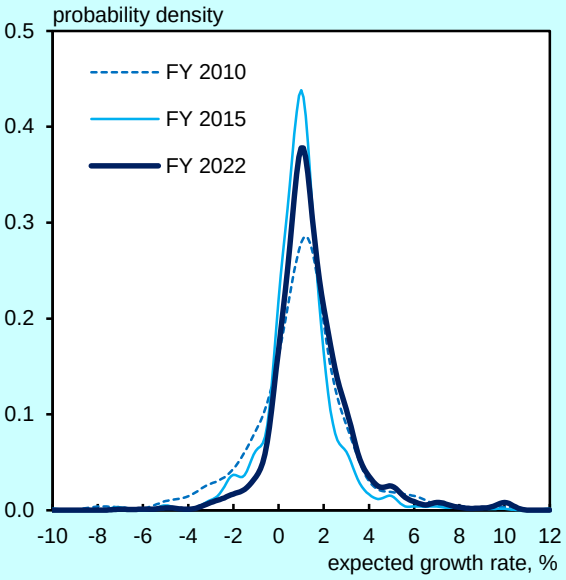
[Chart 9] Expected Growth Rate



Source: Cabinet Office.

Note: Based on the "Annual Survey of Corporate Behavior." "Expected growth rate" is the average of firms' forecasts of the real growth rate of industry demand over the next five years. "Growth rate of capital investment" is the average of the growth rate of firms' planned fixed investment over the next three years. Shaded area indicates the 20-80 percentile band of the expected growth rate.

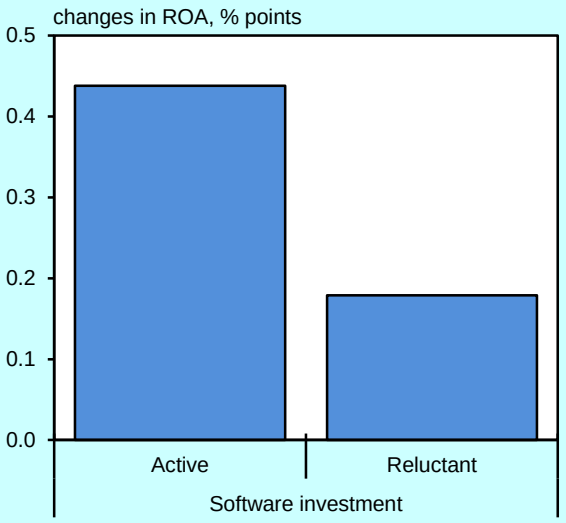
[Chart 10] Expected Growth Rate Distribution



Source: Cabinet Office.

Note: Figures were staff estimates obtained by compiling the questionnaire information from the Cabinet Office's "Annual Survey of Corporate Behavior." Figures show the distribution of firms' forecasts of the real growth rate of industry demand over the next five years.

[Chart 11] Labor-Saving Investment and Capital Efficiency



Sources: Bank of Japan; Ministry of Economy, Trade and Industry.

Note: Figures are calculated by matching microdata from the *Tankan* and the Ministry of Economy, Trade and Industry's "Basic Survey of Japanese Business Structure and Activities." Firms with the ratio of software investment (to total asset ratios) surpassing the median are defined as "active," and those with the ratio below the median as "reluctant." Changes in ROA (cumulative changes from FY 2015 to FY 2021) shows the average.

Concluding Remarks

This paper examines the effects of Japan's declining population on business fixed investment. The results of our analysis using microdata from the *Tankan* show that firms facing labor shortages tend to make active investment in tangible fixed assets and software. Given that labor market conditions are highly likely to remain tight going forward, potential demand for labor-saving investment to address labor shortages appears to be large.

To make this potential demand materialize, what is required is to train up highly skilled personnel who can develop and use labor-saving machines and software, through increased investment in human capital and reskilling. In other words, it is necessary to make investment in machines and software and investment in people simultaneously, and expand areas that can be replaced with machines. In addition to an accumulation of human capital, increased mobility in the labor market, which has started to be seen in recent years, is expected to promote effective reallocation of labor resources and to reduce friction that may occur when replacing labor with capital. In promoting labor-saving investment, it is also important for firms to review their business models and build a framework that enables an effective use of machines. Moreover, maintaining firms' medium- to long-term growth expectations is necessary to increase firms' positive investment. In this regard, institutional support, such as deregulation, would also be beneficial, in addition to firms' own efforts, including creating new demand. Labor-saving investment triggered by labor shortages and accompanying measures is expected to promote firms' labor-saving technological progress, and thereby raise Japan's economic growth rate.

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* Currently at the Personnel and Corporate Affairs Department.

1 For the current situation and outlook for labor market conditions, see Box 2 of the January 2023 *Outlook for Economic Activity and Prices* (Outlook Report).

2 In this paper, the framework of growth accounting is used. For details on the derivation of equations, see the following paper.

Yagi, Tomoyuki, Kakuho Furukawa, and Jouchi Nakajima (2022), "Productivity Trends in Japan -- Reviewing Recent Facts and the Prospects for the Post-COVID-19 Era --," Bank of Japan Working Paper Series, No. 22-E-10.

3 While prior studies have argued that a decline in labor force would slow economic growth, more recent studies have argued that labor shortages would not necessarily exert negative impact on an economy because technological innovation that replaces labor force becomes active amid a declining population (see, for example, the following paper). This paper explains this point empirically.

Acemoglu, Daron and Pascual Restrepo (2021), "Demographics and Automation," *Review of Economic Studies*, Vol.89 (1), pp.1-44.

4 Yagi et al. (2022) summarize the recent discussion regarding labor productivity in Japan.

5 For details on the increase in labor-saving investment before the pandemic, see Box 4 of the July 2018 Outlook Report.

6 For example, a decline in software prices due to progress in IT and an increase in wages owing to labor shortages will lead to a decrease in the relative price of capital to labor, and will encourage firms to become more active in making investment.

7 We estimate the elasticity of substitution between labor and capital (σ) using a constant elasticity of substitution (CES) production function.

$$Y_t = A_t \left[\alpha K_t^{\frac{\sigma-1}{\sigma}} + (1-\alpha) L_t^{\frac{\sigma-1}{\sigma}} \right]^{\frac{\sigma}{\sigma-1}}.$$

Specifically, we obtain σ from the following equation derived from the profit maximization condition under budget constraints.

$$\ln \frac{K_t}{L_t} = -\sigma \ln \frac{r_t}{w_t} + Const. + \varepsilon_t.$$

r denotes rental prices of capital and w denotes wages. See text for the definitions of other notations.

8 For example, the following paper estimates the elasticity of substitution in Japan and the United States, and shows that the elasticity for the United States was 1.47 (estimation period: 1985-2017) while that for Japan was only 0.20 (estimation period: 1988-2017).

Hirakata, Naohisa and Yasutaka Koike (2018), "The Labor Share, Capital-labor Substitution, and Factor Augmenting Technologies," Bank of Japan Working Paper Series, No.18-E-20.

9 The following paper examines the estimates of the elasticity of substitution between labor and capital in the United States obtained in preceding studies. The median of the estimates is around 0.7, but it should be noted that, since estimates differ

across studies, such comparisons need to be interpreted with considerable latitude.

Knoblach, Michael, Martin Roessler, and Patrick Zwerschke (2020), "The Elasticity of Substitution between Capital and Labour in the US Economy: A Meta-regression Analysis," *Oxford Bulletin of Economics and Statistics*, Vol.82 (1), pp.62-82.

[10] The following paper clarifies that firms' demand for highly skilled personnel rises in the process of increasing investment in intangible fixed assets by compiling the questionnaire information of surveys, including the *Basic Survey of Japanese Business Structure and Activities* released by the Ministry of Economy, Trade and Industry.

Furukawa, Kakuho, Yoshihiko Hogen, Yosuke Kido (2023), "Labor Market of Regular Workers in Japan: A Perspective from Job Advertisement Data," Bank of Japan Working Paper Series, No. 23-E-7.

[11] Looking at prior studies that focus on the elasticity of substitution, Katz and Margo (2014) state that capital and labor are complementary to each other and thus capital deepening leads to an increase in demand for highly skilled personnel. In addition, Acemoglu and Restrepo (2018) analyze the impact of automation on labor and argue that, while machines replace simple labor, new complex and high-skilled jobs for using machines are created simultaneously. See the following papers for details.

Katz, Lawrence F. and Robert A. Margo (2014), "Technical Change and the Relative Demand for Skilled Labor: The United States in Historical Perspective," NBER Chapters, in Human Capital in History: The American Record, pp.15-57, National Bureau of Economic Research.

Acemoglu, Daron and Pascual Restrepo (2018), "The Race between Man and Machine: Implications of Technology for Growth, Factor Shares, and Employment," *American Economic Review*, Vol.108 (6), pp.1488-1542.

[12] Furukawa et al. (2023) show that the demand for highly skilled personnel has been increasing in Japan using online job advertisement.

[13] We refer to the following paper for the calculation of rental prices of capital in Chart 7.

Jorgenson, Dale W. (1963), "Capital Theory and Investment Behavior," *American Economic Review*, Vol.53 (2), pp.247-259.

[14] The following paper points out that the relative price of capital have declined in the United States due to a progress in IT and that such decline has led to the substitution of labor for capital. See the following for more details.

Karabarbounis, Loukas and Brent Neiman (2014), "The Global Decline of the Labor Share," *The Quarterly Journal of Economics*, Vol.129 (1), pp.61–103.

[15] For the expansion in the labor market for job changers in recent years, see Box 1 of the October 2023 Outlook Report.

[16] In the discussion of secular stagnation, which attracted worldwide attention before the pandemic, a decline in demand for investment due to demographic changes is considered as an important channel through which the natural rate of interest is pushed down.

[17] However, it is worth noting that the survey is conducted for listed firms and thus the results are mainly for large firms. It is likely that growth expectations for SMEs have not been as high as those for large firms, as it is not easy for SMEs to respond to global demand.

[18] Firms' fixed investment stance has been active in recent years regardless of firm size. In the December 2023 *Tankan*, firms' fixed investment plans for 2023 were at high levels. In addition, the *Annual Survey of Corporate Behavior* mentioned above shows that the outlook for fixed investment by large firms marked the highest level since fiscal 1990 (Chart 9).

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