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Employer-Provided Training and Productivity: Evidence from a Panel of Japanese Firms*

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Abstract

This study presents evidence on the quantitative relationship between employer-provided training and productivity among Japanese firms. The important contributions of this study are its construction of a panel of training stock at the firm-level, its distinction between manufacturing and service firms, and its comparison of the relative contribution of training to productivity and wages. The results indicate, first, that training significantly contributes to the labor productivity of the firm. Second, the estimated elasticity of productivity with respect to training stock is greater for service firms than for manufacturing firms. Third, the elasticities of productivity and wages to training stock are similar in size, meaning that the returns to firms' training investments are shared by their workers in proportion to the wage share of the value-added. These results suggest that policies to promote firms' training investments have the potential to improve productivity and wages, particularly for firms in service sector.

Keywords: Training, Labor productivity, Wage, Service sector, Intangible assets

JEL Classification: J24, J31, J53, L80, M53

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1. Introduction

In light of Japan's declining growth rate, upgrading human capital to improve productivity performance has become an important item on the national policy agenda. An improvement in the quality of the workforce (e.g., an increase in the number of highly educated workers) has contributed to the economic growth rate by 0.5-0.6% points per annum throughout the past two decades.[1]

In addition to education, employer-provided training — On-the-job training (OJT) and Off-the-job-training (Off-JT) — is an important form of human capital investment. The effect of work experience on wages that is usually found in standard wage function estimations reflects that employer-provided training is a kind of learning-by-experience. Intangible capital, the role of which is stressed in recent productivity studies, includes firm-specific human capital as a subset of "economic competencies" (Corrado *et al*., 2009; Fukao *et al*., 2009). In the empirical studies of intangible investments, firm-specific human capital is estimated as the cumulative sum of employer-provided training expenditures.

Employer-provided training has stagnated, however, since the global financial crisis. According to the Basic Survey of Human Resources Development conducted by the Ministry of Health, Labour, and Welfare, training expenditures declined in Japanese firms until 2013 and only weakly recovered afterwards (**Figure 1**).[2] Against this background, the "Human Resources Development Revolution" became a pillar of the Japanese government's recent economic growth strategy. In addition to pecuniary support for education, including the expansion of free preschool and higher education for children in low-income households, in 2018 the government introduced corporate tax deductions for small- and medium-sized enterprises (SMEs) that increased training expenditures as well as subsidies for employer-provided training.

The implicit assumption behind these policies to support firms' investments in human resource

[1] The growth accounting figure is taken from the Japan Industry Productivity Database (Research Institute of Economy, Trade and Industry: RIETI).

[2] According to the Survey, firms' training expenditure is defined as "the expenses for Off-JT and pecuniary support for worker-initiated training." Microdata from the Basic Survey of Human Resources Development, are used, for example, in Kwon *et al*. (2012) and Hara (2017).

development is that actual investments are lower than is socially desirable. Theoretically, determinations of whether firms are truly underinvesting in training depend on various factors: the quantitative contribution of employer-provided training to productivity; whether the skill acquired through the training is general or firm-specific; the division of investment benefits or returns between firms and workers; and the degree of market imperfection in capital and labor markets (see Leuven, 2005 for a survey of this literature). In order to establish appropriate policy measures, empirical studies on training's productivity impact and on the distribution of training investment benefits between firms and workers are indispensable. However, past empirical studies on employer-provided training have had many limitations. In particular, formal econometric studies of large panels of firms (including SMEs) have been scarce in Japan. Comparisons between manufacturing and service sectors in terms of training impact on firm performance also have been rare, even in other advanced economies.[3]

This study contributes to the literature and to the related policy planning by illustrating the quantitative relationship between human capital stock from firm-provided training and the productivity and wages of firms. It draws upon a large panel data set from the Basic Survey of Japanese Business Structure and Activities (BSJBSA), conducted by the Ministry of Economy, Trade, and Industry for the years 2009–2016. It should be mentioned that the human resource investments in the BSJBSA are limited to Off-JT. Traditionally, with lifelong employment practices and the seniority wage system, informal OJT has been viewed as the main way to improve productivity in Japanese firms. With the changing structure of the Japanese labor market, though, the role of Off-JT has increasingly attracted the attention of firm managers. In addition, as the Japanese Government has recently expanded tax and subsidization measures to promote formal employee training programs, a study on the impact of Off-JT has the potential to inform the policy planning in Japan.

A preview of this study's major results is as follows: first, firm-provided training significantly contributes to the labor productivity of the firm, and the rate of return on investments is higher than that from investments in tangible capital. Second, the elasticity of productivity with respect to training stock is significantly greater for service firms than for manufacturing firms. Third, the elasticities of productivity and wages with respect to training stock are similar in size, meaning

[3] A rare example is Konings and Vanormelingen (2015), which, using a panel data of Belgian firms, compare the impact of formal training on productivity and wages between manufacturing and non-manufacturing firms.

that the returns to employer-provided training are shared by their workers in proportion to the labor share of the value-added.

The rest of this paper is structured as follows. Section 2 briefly reviews the literature. Section 3 explains the data used in this study and the method of analysis, including the construction of the training stock variable. Section 4 reports and interprets the results, and Section 5 concludes with the policy implications.

2. Literature Review

There have been a large number of studies on the effects of firm-provided training on employee wages (Barron *et al*., 1989; Brown, 1989; Lynch, 1992; Booth, 1993; Frazis and Loewenstein, 2005; Melero, 2010; Brunello *et al*., 2012). Most of them find that OJT and Off-JT have positive impacts on wages, suggesting that training does indeed improve the productivity of workers. Some studies used direct measures of worker productivity to show the impact of training on productivity (De Grip and Sauermann, 2012).

Studies that used aggregate industry-level data to analyze the impact of firm-provided training on productivity include Conti (2005) in Italy and Dearden *et al*. (2006) in the UK. Both studies indicated positive effects on productivity from training. A growing number of studies have used firm-level micro data to estimate training impact. Although some earlier influential studies did not detect productivity enhancements from training (Black and Lynch, 1996; 2001), the majority of studies demonstrated evidence of positive impact (Bartel, 1994; Barron *et al*., 1999; Barrett and O'Connell, 2001; Zwick, 2006; Ballot *et al*., 2006; Konings and Vanormelingen, 2015; Feltrinelli *et al*., 2017; Higon *et al*., 2017). Analytical methods have progressed to the use of panel data and the construction of training stock variables.

Several studies have measured the rate of return on training investments (for surveys see Blundell *et al*., 1999; Bartel, 2000). Bartel (2000) maintained that the "employer's return on investment in training may be higher than previously believed." In a recent study of return rates using panel data from large Portuguese firms, Almeida and Carneiro (2009) estimated that the rate of return on formal job training is 8.6%, meaning that formal job training is a wise investment for firms, with returns that are comparable to investments in physical capital.[4]

Among the empirical studies mentioned above, some compared the impact of training on productivity and wages (Barron *et al*., 1999; Conti, 2005; Ballot *et al*., 2006; Dearden *et al*., 2006; Konings and Vanormelingen, 2015). The relative strength of the impact on productivity, wages, and, in turn, profitability, has an important implication—it affects incentives for firms to invest in the human capital of their employees. Past studies generally showed that the productivity effect was larger than the wage effect, meaning that firms could capture a large portion of the return on their investments. This is an understandable result as training expenditures are intended to upgrade firm-specific skills.

Formal econometric studies on the relationship between firm-provided training and productivity have been limited in Japan, but Kurosawa *et al*. (2007), Miyagawa *et al*. (2011), and Kwon *et al*. (2012) are a few examples of such analyses. Kurosawa *et al*. (2007) used survey data from about 800 manufacturing plants to estimate the relationship between training, productivity, and wages. They reported that Off-JT had a significant positive impact on plant productivity, while the impact of OJT was insignificant. In addition, although Off -JT had a positive impact on wages, the size of its coefficient was smaller than that for productivity. According to their estimation, a 40% to 50% improvement in productivity was captured by employees through higher wages.

Miyagawa *et al*. (2011) used survey data from about 400 firms to estimate the production function and found a positive association between training and productivity. Kwon *et al*. (2012) drew upon cross-sectional data from 4000 establishments in the Basic Survey of Human Resources Development to show a positive association between OJT and productivity, while the association was insignificant for productivity and Off-JT. The productivity measure in their analysis was a 5-point scale subjective assessment relative to other firms in the same industry.[5]

In sum, despite the fact that human capital investments have been emphasized recently in the Japanese economic policy arena, previous empirical studies on the impact of training on firm

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[4] Dostie (2018), using survey data for Canadian firms, estimates the impact of training investments on innovation and finds that both OJT and Off-JT have positive impacts on product and process innovations.

[5] In addition to the studies mentioned in the text, Ariga *et al*. (2013), which was based on a survey for two automobile assemblers, reported that OJT had a significant positive effect on workers' subjective assessment of their productivity. Hara (2014), using worker-level survey data, analyzed the effect of firm-provided training on skills, productivity, and wage growth of non-regular employees in Japan and found evidence of productivity improvements as an effect of training.

productivity have been limited to cross-sectional estimations and to studies of small numbers of firms. In addition, studies of relevant differences between manufacturing and service sectors have also been rare, not only in Japan but also in other countries.

Against this background, this study conducts econometric analysis on the relationship between employer-provided training and productivity and wages by using a large panel data set from the BSJBSA. The contributions of this study to the literature are as follows. First, in contrast to previous studies, we draw upon a firm-level, large panel data set including both large firms and SMEs. Second, in contrast to most past studies in Japan, we construct and use a stock variable for training. Third, we compare firms operating in manufacturing sector with those in service sector. Fourth, we estimate both productivity and wage equations to quantitatively assess the return-on-training-investment distributions between firms and workers. Fifth, we consider the measures of other types of intangible capital such as research and development (R&D), information and communications technology (ICT), and advertisement stocks to address possible omitted variable bias arising from the complementarity between human capital and these other intangibles.

3. Data and Method of Analysis

This study uses micro data taken from the BSJBSA for the fiscal years 2009 to 2016. The BSJBSA, an annual survey first administered in fiscal year 1991, has frequently been used in empirical studies of Japanese firms. It provides official statistics for all Japanese firms with 50 or more regular employees whose paid-up capital is 30 million yen or over engaged in the mining, manufacturing, electricity and gas, wholesale, retail, and several service industries. Approximately 30,000 firms are surveyed every year. The purpose of the BSJBSA is to capture comprehensive information about Japanese firms: such as their basic financial information (e.g., sales, costs, profits, book value of capital); the number of employees, establishments, and subsidiaries; R&D expenditure; and international trade. As the BSJBSA is a fundamental statistical survey designated as such by the Statistics Act, firms are obligated to report.

The BSJBSA began collecting information on firms' annual Off-JT related expenditures (million yen) in fiscal year 2009. The Off-JT related expenditure is defined as the sum of payments for instructors, teaching materials, outsourced instruction, tuition, and subsidies for employees' voluntary educational expenses. We construct a stock measure of training investments from the annual expenditure flows using the standard perpetual inventory method. The depreciation rate of the training stock is set to 40%, which is adopted from representative studies on intangible capital (Corrado *et al*., 2009; Fukao *et al*., 2009), as the baseline figure. However, as some past studies that estimate training stock using the perpetual inventory method assume a depreciation rate of 15-20%,[6] we use 20% as an alternative for robustness check purpose. The depreciation rate of human capital stock at the firm-level includes both the technical obsolescence of the skills and the loss arising from between-firm turnover of workers.[7]

Although eight years of observations are available; we focus on five consecutive years of training expenditures in constructing the stock variable in order to enable panel regression analysis. For example, training stock in 2013 is calculated as the cumulative sum of the training expenditures from 2009 to 2013 after taking depreciation into account. Therefore, in conducting fixed-effects (FE) estimations, four years of panel data from 2013 to 2016 are used. The number of sample firms is restricted to those responding to the BSJBSA for five consecutive years, and the total number of observations and firms are 90,125 and 26,668, respectively. In addition to the training stock, other stocks of intangible capital available from the BSJBSA—specifically, R&D, information technology (IT), and advertisement stocks—are considered in the extended regressions. Among these intangibles, IT capital is proxied by the stock series of the book value of software assets. As R&D and advertisement are flow series, stock variables are constructed similarly to the training by the perpetual inventory method from five consecutive years of observations. The depreciation rates are assumed as 20% for R&D and 60% for advertisement, adopted from past studies on intangible capital (Corrado *et al*., 2009; Fukao *et al*., 2009).

By using this panel data set, FE estimations are conducted, where the dependent variables are labor productivity ($ln(LP)_{it}$) and average wages ($ln(Wage)_{it}$). The main explanatory variable is the training intensity (training stock per employee: $ln(Training)_{it}$). All the variables (expressed in logs) are the price-unadjusted nominal figures, mainly because appropriate deflators for training and other intangibles are unavailable. However, the difference that inflation adjustment makes is likely to be limited, because the inflation rate in Japan had been almost zero during the sample period. In addition, as industry*year dummies (λ_{jt}) are included in the estimations, industry-

[6] For example, Conti (2005) and Almeida and Carneiro (2009) assumed depreciation rates of training stock as 15% and 17%, respectively.

[7] According to the Survey on Employment Trends (Ministry of Labour, Health and Welfare), the recent separation rate in Japan is about 15%.

specific price movements are removed.

Labor productivity is calculated as the value-added divided by the number of employees.[8] Average wages are the total compensation including the bonus divided by the number of employees. The control variables are the capital intensity ($ln(Tangible)_{it}$: the book value of fixed tangible assets divided by the number of employees) and the ratio of part-time employees to total employees ($Part_{it}$). Obviously, the inclusion of capital intensity is because the dependent variable is labor productivity (and not total factor productivity). The share of part-time employees is used to control for different working hours and the labor quality between full-time and part-time employees. Three-digit industry*year dummies (λ_{jt}) are included to control time-variant industry characteristics. As the main variables of interest are expressed in logs, the equation to explain labor productivity is a variant of a standard production function estimation. The baseline FE equations to be estimated are expressed as follows, where η_i denotes firm fixed-effects.

$$ln(LP)_{it} = \alpha + \beta\ ln(Training)_{it} + \gamma\ ln(Tangible)_{it} + \delta\ Part_{it} + \lambda_{jt} + \eta_i + \varepsilon_{it} \qquad (1)$$

$$ln(Wage)_{it} = \alpha + \beta\ ln(Training)_{it} + \gamma\ ln(Tangible)_{it} + \delta\ Part_{it} + \lambda_{jt} + \eta_i + \varepsilon_{it} \qquad (2)$$

In the expanded estimations, R&D stock per employee ($ln(R\&D)_{it}$), software assets per employee ($ln(Soft)_{it}$), and advertisement stock per employee ($ln(Advertise)_{it}$) are included as additional explanatory variables. In these estimations, industry-specific economic fluctuations are removed by the inclusion of industry*year dummies, and the unobservable time-invariant firm characteristics are controlled by the firm fixed-effects. Although the estimations cannot completely eliminate the possible endogeneity of training, the reverse causality running from productivity to training is substantially reduced by using the stock measure of accumulated training.

It should be mentioned that as the main explanatory variables are expressed in logs, firms with zero training expenditure (and other investments) throughout the five years are dropped from the regressions. As a relatively large number of firms do not invest in intangible capital, the number of observations is substantially reduced, particularly in estimations including various intangible assets. In order to deal with this issue, we conduct supplementary regressions by replacing zero

[8] Value-added is calculated as the sum of the operating profit, rent, wages (including bonus), depreciation, and paid tax.

with 0.001 (one thousand yen) to observe the differences.

The summary statistics of the training stock are presented in **Table 1**. As we are interested in the differences between manufacturing and service firms, separate statistics for the subsamples by sector are also reported in the table. The service firms in this study are those classified as wholesale, retail, information and communications, and other service industries. The summary statistics when a 20% depreciation rate is assumed and when zero is replaced by 0.001 are presented in **Appendix Table A1**.

4. Results

4.1. Overview of the Firm-Provided Training

First, we present an overview of descriptive statistics on recent trends in employee-provided training in Japan. **Table 2** shows the distributional characteristics of the training stock per employee. Log transformation is not applied in this table. The sample mean is 23,400 yen, and the figure for the subsample of service firms (24,700 yen) is somewhat larger than that for manufacturing firms (21,200 yen).

The median of the training stock is zero, meaning that more than half of firms do not invest in any formal training (Off-JT) during the five consecutive years. The right end of the table shows the share of observations with non-zero training stock: 45.6% of all observations. The dispersion of training intensity across firms is very large: the 90th and 95th percentile figures are 64,000 and 106,100 yen, respectively. Although service firms exhibit somewhat higher training intensity, the skewed distribution is common across sectors.

In order to observe which firm characteristics are associated with the training intensity, we conduct simple regressions to explain training stock per employee (expressed in a log) or the firm's decision to invest in training. The explanatory variables included are firm size (log capital), firm age, share of part-time employees, and three-digit industry*year dummies. Column (1), (2), and (3) of **Table 3** are the OLS, probit, and tobit estimation results, respectively. Irrespective of the estimation method, the coefficients for firm size are positive, and those for share of part-time employees are negative. These coefficients are statistically significant at the 1% level. In contrast, the coefficients for firm age are rarely significant. As expected, large firms with a high share of full-time employees tend to conduct formal training more intensively.

4.2 Training and Firm Productivity

Columns (1)-(3) of **Table 4** report baseline FE estimation results to explain labor productivity (equation (1)). Columns (4)-(6) of the table indicate the OLS estimation results for comparison purpose. The coefficients for training intensity are positive and highly significant, indicating the positive impact of training investments on firm productivity. The size of the coefficients in the FE estimations are less than half of the coefficients in the OLS, indicating that unobservable firm characteristics significantly affect the association between training and productivity. Other things being equal, the more productive firms tend to make more investments in training. The result suggests that past studies that depend on cross-sectional data are likely to overestimate the effect of training on productivity. As both labor productivity and training intensity are expressed in logs, the estimated coefficient can be interpreted as the elasticity of productivity with respect to training intensity. The coefficient for training in the FE estimation is 0.0220 for all firms (column (1)), meaning that a 1% increase in training stock per employee is associated with about a 0.02% higher productivity.

By sector, the coefficients are 0.0097 and 0.0321 in the subsamples of manufacturing and service firms, respectively. The positive contribution of training to productivity is far larger in the service sector than in the manufacturing sector. Some past empirical studies have focused only on the manufacturing industry due to data constraints, but our result suggests that these studies may underestimate the role of Off-JT in explaining productivity. The greater contribution of training to productivity in the service sector is similar to the finding by Konings and Vanormelingen (2015) for training in Belgian firms. The sectoral difference is remarkable, however, in Japanese firms.

Although it is not a focus of this study, the coefficients for tangible capital and part-time share are both significant at the 1% level, and the sizes of negative coefficients for the part-time share are large. The relatively larger negative coefficients in the subsample of service firms mainly reflects the fact that working hours of part-time employees in the service sector are generally shorter than those of part-time employees in the manufacturing sector. We will discuss the role of part-time workers on firm productivity in greater detail in the next subsection.

The baseline results presented above assume a 40% depreciation rate of training stock. Similar

FE estimation results by assuming a depreciation rate of 20% are reported in columns (1)-(3) of **Appendix Table A2**. In this case, the size of the coefficient for training intensity is about 47% larger than the baseline estimation (column (1)). This result suggests that reducing the separation rate of employees, which contributes to a reduction in depreciation rate, positively contributes to firms' efficiency in training investments.

The results of supplementary regressions, replacing training stock of zero with 0.001 (one thousand yen), are reported in columns (4)-(6) of **Appendix Table A2**. In this case, the size of the estimated coefficients for training intensity drop substantially. This result suggests that estimations of intensive margin using a sample of firms with non-zero training stock may overstate the impact of training on productivity. However, even in these estimations, the coefficients for training intensity are statistically significant at the 1% level for all firms and the subsample of service firms and at the 5% level for the subsample of manufacturing firms. As discussed later, the rate of return on training investments is very high, at least for all firms and for the subsample of service firms.

Table 5 shows the estimation results including per employee R&D stock ($ln(R\&D)_{it}$), software assets ($ln(Soft)_{it}$), and advertisement stock ($ln(Advertise)_{it}$) as additional explanatory variables. In this case, the number of observations is reduced substantially, because observations in which at least one intangible stock has zero value are dropped from the estimations. In the OLS estimations (columns (4)-(6)), the coefficients for all explanatory variables are significant at the 1% level, but in the FE estimations (column (1)-(3)), some coefficients lose statistical significance. In particular, the coefficient for training intensity is insignificant for the manufacturing industry. However, the coefficients are significant for all firms and the subsample of service firms, and the sizes of the coefficients are similar to the baseline results reported in **Table 4**. To compare coefficients for the other intangible assets by industry, the coefficients for software and advertisement are insignificant for the manufacturing industry. This result suggests the important role of intangible assets in the productivity of the service sector.

The FE estimation results of the same specification by assuming a depreciation rate of 20% are reported in columns (1)-(3) of **Appendix Table A3**. The results for replacing zero training stock with 0.001 are reported in columns (4)-(6) of the table. The coefficients for training intensity are generally similar to the specification without accounting for the other intangible assets reported in **Appendix Table A2**, although the coefficient for training loses statistical significance for the subsample of manufacturing firms when assuming a 20% depreciation rate (column (2)).

Based on the estimation results presented above, we can calculate the rate of return on training investments. Specifically, the rate of return can be obtained by dividing the estimated coefficient (or elasticity) by the ratio of training stock to the value-added.[9] The calculation results are summarized in **Table 6**. As the training stock value is very small compared to the value-added, the average rate of return to training is very high: about 260% in the baseline FE estimation for all firms (panel A of the table). The rates are about 110% and 420% for the manufacturing and service sectors, respectively. Even if we use the lower estimation results (column (4) of **Appendix Table A3**) that include observations with no training stock, the rate of return is about 150%. The figures for the subsamples of manufacturing and service firms are about 90% and 250%, respectively.

However, we should bear in mind that as the BSJBSA does not contain information about the opportunity costs of training (work hours lost during participation in the training), the figures presented above are calculated based only on the direct costs of training reported in the BSJBSA. According to the Cabinet Office (2018), the opportunity costs of Off-JT are estimated to be 11.3 times the direct costs, on average.[10] This figure is not directly applicable to the sample used in this study, because those opportunity costs were based on a different survey conducted in 2018 by the Cabinet Office. However, as a thought experiment, we can estimate the rate of return by multiplying the training stock by 12.3 (=1+11.3). The results are reported in panel B of **Table 6**. The average rates of returns are about 21%, 9%, and 34% for all, manufacturing, and service firms, respectively. This result suggests underinvestment in training, particularly for firms in the service sector.

4.3. Training and Wages

Columns (1)-(3) of **Table 7** present baseline FE estimation results to explain the average wages of firms (equation (2)). Column (4)-(6) of the table indicate the OLS estimation results for

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[9] The calculation, following past studies on R&D investments (Hall *et al*., 2010), is based on the formula $\gamma=\rho(K/Y)$ where, K, Y, γ, and ρ denote training stock, value-added, elasticity of value-added with respect to training stock, and rate of return to training stock (=marginal productivity), respectively. In the calculation presented in the text, K and Y are the means of the observations used in the regressions.

[10] The details of the Cabinet Office (2018) estimation were reported in Kodera and Inoue (2018).

comparison purpose. Although the coefficients for training intensity are positive and statistically significant at the 1% level, the sizes of the coefficients in the FE estimations are smaller than the coefficients obtained from the OLS, similar to the finding in the productivity equation, meaning that unobservable firm characteristics significantly affect the cross-sectional relationship between training intensity and wages.

The coefficient for training in the FE estimation is 0.0223 for all firms (column (1)), meaning that a 1% increase in training stock per employee is associated with about a 0.02% higher mean wage. Interestingly, the size of the coefficient is very close to that for the productivity equation with the same specification (0.0220, reported in **Table 4**). For the subsamples of manufacturing and service firms, the elasticities of productivity and wages with respect to training intensity are also similar in size (columns (2) and (3)). Although the costs of Off-JT are borne by firms, the return from training is partially captured by their employees, proportional to the labor share of the value-added.

Theoretically, in a competitive labor market, workers pay the full costs (through lower wages) and reap the returns from general (not firm-specific) training. On the other hand, employers pay the full costs and reap the returns from firm-specific training (see, for example, Leuven, 2005). The result of this study differs from the standard theoretical prediction and suggests a mechanism of labor rent sharing in an imperfect labor market. Although several studies outside Japan have confirmed that workers benefit from training through higher wages, the impact of training on firm productivity is generally larger than the impact on wages (Barron *et al*., 1999; Conti, 2005; Dearden *et al*., 2006; Konings and Vanormelingen, 2015). In this respect, in the Japanese labor market, workers acquire a relatively larger portion of the return from training. We conjecture that the low between-firm mobility of workers in a long-term employment system may be a cause of the different result for Japanese firms.

The rate of return calculation in the previous subsection treated increased value-added as the return from training investments. However, from the viewpoint of firms (or shareholders), the rate of return calculation should be based only on the portion of the return that accrues to firms. If we remove the labor share of the increased value-added, the rate of return in the baseline estimation is reduced from 264% to 79%. If the opportunity costs of training (or lost working hours) are roughly adjusted, the rate is reduced from 21% to about 6%.

According to the FE estimation results for the subsamples of manufacturing and service firms (columns (2) and (3)), the elasticities of average wages with respect to training intensity are

0.0108 for manufacturing sector and 0.0443 for service sectors. Similar to the result for the productivity equation, the effect of training on wages is far greater in the service sector. Konings and Vanormelingen (2015) demonstrated that the impact of training on wages is somewhat larger for manufacturing compared to non-manufacturing firms. The results of this study differ from theirs.

Although it is not a focus of this study, the coefficients for the share of part-time employees have a large negative value and are statistically significant at the 1% level. In the case of the FE estimation for all firms, the coefficient is -0.3665, which is close to that for the productivity equation with the same specification (-0.3741, reported in **Table 4**). This result suggests that the wages of part-time employees reflect, at least on average, their contribution to firm productivity. Recent policy discussion on "equal pay for equal work" has highlighted the relatively low wages of non-standard workers, including part-time workers. The results of this study, however, suggest that reducing the wage inequality between full-time and part-time employees hinges on enhancing the productivity of those who work part-time.[11]

The FE estimation results assuming a depreciation rate of 20% are reported in columns (1)-(3) of **Appendix Table A4**. Similar to the results for labor productivity, the sizes of the coefficients are larger than the baseline results, irrespective of sector. The results for replacing zero training stock with 0.001 are reported in columns (4)-(6) of the table. Different from the results for labor productivity, the coefficients for training intensity are positive and significant at the 1% level, even for the subsample of manufacturing firms. Throughout the estimations, the sizes of the coefficients for training intensity are larger for service than for manufacturing firms. In short, employer-provided Off-JT contributes positively to both productivity and wages, particularly for firms in service sector.

Table 8 shows the estimation results including per employee R&D stock ($ln(R\&D)_{it}$), software assets ($ln(Soft)_{it}$), and advertisement stock ($ln(Advertise)_{it}$) as additional explanatory variables. According to the FE estimation results (column (1)-(3)), the sizes of the coefficients for training are similar to or somewhat larger than the regression results without these additional variables. The sizes of the coefficients for these intangible assets as well as for tangible capital are larger for

[11] Morikawa (2017), by using different data and methodology, indicated that the wage level of part-time workers reflected their contribution to firm productivity in Japan. Garnero *et al*. (2017) estimated the productivity-wage gap of part-time workers in Belgium and found that part-time workers generated employer rents.

service firms than manufacturing firms. The result suggests that investments in tangible and intangible capital can play a role in increasing wages in the service sector.

The FE estimation results assuming a depreciation rate of 20% are reported in columns (1)-(3) of **Appendix Table A5**. The results of replacing zero training stock with 0.001 are reported in columns (4)-(6) of the table. The coefficients for training intensity are generally not much different from the specification without accounting for the other intangible stocks reported in **Appendix Table A4**.

5. Conclusions

Using firm-level panel data from the BSJBSA for the years 2009–2016, this study explores the quantitative relationship between employees' human capital derived from employer-provided Off-JT and productivity and wages in Japanese firms. Despite the practical importance of upgrading human capital to improve productivity, there have been very few formal empirical studies of this subject using firm-level large panel data. This study aims to contribute to the literature as well as to the policy planning by constructing the stock measure of training intensity to compare the impacts of employer-provided training on productivity and wages. In addition, this study presents novel evidence on the different effects of Off-JT in the manufacturing and service sectors.

The major findings and their implications can be summarized as follows. First, firm-provided Off-JT significantly contributes to firm productivity, and the rate of return for training seems to be higher than that for investments in physical capital. Traditionally, OJT is regarded as integral to the performance of Japanese firms, particularly for those in manufacturing sector. However, with the changing structure of the economy, Off-JT is becoming an important intangible investment to improve firms' productivity. Second, the estimated elasticity of productivity with respect to training intensity is far greater for firms operating in service sector than for those in manufacturing sector. This result suggests underinvestment in the service sector in formal training that will upgrade human capital of employees. Third, the returns to firm-provided training investments are shared by the firms and their employees proportional to the factor shares of the value-added. This result differs from past studies in the United States and Europe, which generally indicated that the effects of training on productivity are larger than those on wages. In Japan, workers capture a relatively larger portion of the additional value that stems from firm-provided training. As this study focuses on labor productivity and average wages at the firm level, the estimated impacts of training include not only direct effects on workers who received training but also indirect effects on other workers in the same firms who did not receive the training, through the positive spillover effect. The findings of this study suggest that recent policy initiatives to promote employer-provided training have the potential to boost productivity, especially in the service sector. However, in order to draw firm conclusions, it would be necessary to conduct ex post quantitative evaluations of the causal impacts of specific policy measures—such as special tax treatments and subsidies—on firms' training investments.

Finally, it should be noted that this study has several limitations. First, we cannot completely eliminate the possibility of endogeneity in the training. The inclusion of industry*year fixed-effects controls for industry-specific shocks during the sample period. In addition, as we construct the stock measure of training intensity instead of the flow measure of a single year, the endogenous response of training investments in estimating production fluctuation is reduced. However, an endogeneity concern remains in that firms continuously invest in training by anticipating firm-specific positive productivity shocks. Second, the BSJBSA used in this study does not contain detailed information about the characteristics of employees, such as gender, age, education, and experience. As the estimations include firm fixed-effects, the results are not affected by the differences in employee characteristics between firms. Although it is unlikely that the characteristics of employees drastically changed over the four years, we cannot rule out a possible omitted variable bias. Third, the estimations are based only on the direct costs of training, because the BSJBSA does not have information about training opportunity costs (working hours lost during participation in Off-JT). We provide the rate of return of training by roughly adjusting for the opportunity costs, but the calculation is far from perfect. Finally, the focus of this study is limited to Off-JT. As policy measures to support firms' training investments generally focus on Off-JT, our focus on Off-JT is appropriate. However, it would be optimal to include both Off-JT and OJT in studies to arrive at a more comprehensive understanding of firms' human capital investments.

References

Almeida, Rita and Pedro Carneiro (2009), "The Return to Firm Investments in Human Capital," *Labour Economics*, Vol. 16, No. 1, pp. 97–106.

Ariga, Kenn, Masako Kurosawa, Fumio Ohtake, Masaru Sasaki, and Shoko Yamane (2013), "Organization Adjustments, Job Training and Productivity: Evidence from Japanese Automobile Makers," *Journal of the Japanese and International Economies*, Vol. 27, No. 1, pp. 1–34.

Ballot, Gerard, Fathi Fakhfakh, and Erol Taymaz (2006), "Who Benefits from Training and R&D, the Firm or the Workers?" *British Journal of Industrial Relations*, Vol. 44, No. 3, pp. 473–495.

Barrett, Alan and Philip J. O'Connell (2001), "Does Training Generally Work? The Returns to In-Company Training," *Industrial and Labor Relations Review*, Vol. 54, No. 3, pp. 647–662.

Barron, John M., Dan A. Black, and Mark A. Loewenstein (1989), "Job Matching and On-the-Job Training," *Journal of Labor Economics*, Vol. 7, No. 1, pp. 1–19.

Barron, John M., Mark C. Berger, and Dan A. Black (1999), "Do Workers Pay for On-The-Job Training?" *Journal of Human Resources*, Vol. 34, No. 2, pp. 235–252.

Bartel, Ann P. (1994), "Productivity Gains from the Implementation of Employee Training Programs," *Industrial Relations*, Vol. 33, No. 4, pp. 411–425.

Bartel, Ann P. (2000), "Measuring the Employer's Return on Investments in Training: Evidence from the Literature," *Industrial Relations*, Vol. 39, No. 3, pp. 502–524.

Black, Sandra E. and Lisa M. Lynch (1996), "Human-Capital Investments and Productivity," *American Economic Review*, Vol. 86, No. 2, pp. 263-267.

Black, Sandra and Lisa Lynch (2001), "How to Compete: The Impact of Workplace Practices and Information Technology on Productivity," *Review of Economics and Statistics*, Vol. 83, No. 3, pp. 434–445.

Blundell, Richard, Lorraine Dearden, Costas Meghir, and Barbara Sianesi (1999), "Human Capital Investment: The Returns from Education and Training to the Individual, the Firm and the Economy," *Fiscal Studies*, Vol. 20, No. 1, pp. 1–23.

Booth, Alison L. (1993), "Private Sector Training and Graduate Earnings," *Review of Economics and Statistics*, Vol. 75, No. 1, pp. 164–170.

Brown, James N. (1989), "Why Do Wages Increase with Tenure? On-the-Job Training and Life-Cycle Wage Growth Observed within Firms," *American Economic Review*, Vol. 79, No. 5, pp.

971–991.

Brunello, Giorgio, Simona Lorena Comi, and Daniela Sonedda (2012), "Training Subsidies and the Wage Returns to Continuing Vocational Training: Evidence from Italian Regions," *Labour Economics*, Vol. 19, No. 3, pp. 361–372.

Cabinet Office (2018), *Annual Report on the Japanese Economy and Public Finance 2018*. (in Japanese)

Conti, Gabriella (2005), "Training, Productivity and Wages in Italy," *Labour Economics*, Vol. 12, No. 4, pp. 557–576.

Corrado, Carol, Charles Hulten, and Daniel Sichel (2009), "Intangible Capital and U.S. Economic Growth," *Review of Income and Wealth*, Vol. 55, No. 3, pp. 661–685.

Dearden, Lorraine, Howard Reed, and John Van Reenen (2006), "The Impact of Training on Productivity and Wages: Evidence from British Panel Data," *Oxford Bulletin of Economics and Statistics*, Vol. 68, No. 4, pp. 397–421.

De Grip, Andries and Jan Sauermann (2012), "The Effects of Training on Own and Co-worker Productivity: Evidence from a Field Experiment," *Economic Journal*, Vol. 122, May, pp. 376–399.

Dostie, Benoit (2018), "The Impact of Training on Innovation," *ILR Review*, Vol. 71, No. 1, pp. 64–87.

Feltrinelli, Elena, Roberto Gabriele, and Sandro Trento (2017), "The Impact of Middle Manager Training on Productivity: A Test on Italian Companies," *Industrial Relations*, Vol. 56, No. 2, pp. 293–318.

Frazis, Harley and Mark A. Loewenstein (2005), "Reexamining the Returns to Training: Functional Form, Magnitude, and Interpretation," *Journal of Human Resources*, Vol. 40, No. 2, pp. 453–476.

Fukao, Kyoji, Tsutomu Miyagawa, Kentaro Mukai, Yukio Shinoda, and Konomi Tonogi (2009), "Intangible Investment in Japan: Measurement and Contribution to Economic Growth," *Review of Income and Wealth*, Vol. 55, No. 3, pp. 717–736.

Garnero, Andrea, Stephaan Kampelmann, and Francois Rycx (2014), "Part-Time Work, Wages, and Productivity: Evidence from Belgian Matched Panel Data," *Industrial and Labor Relations Review*, Vol. 67, No. 3, pp. 926–954.

Hall, Bronwyn H., Jacques Mairesse, and Pierre Mohnen (2010), "Measuring the Returns to R&D," in Bronwyn H. Hall and Nathan Rosenberg eds. *Handbook of the Economics of*

Innovation, Volume 2, The Netherlands: Elsevier B.V., Ch. 24, pp. 1034–1082.

Hara, Hiromi (2014), "The Impact of Firm-Provided Training on Productivity, Wages, and Transition to Regular Employment for Workers in Flexible Arrangements," *Journal of the Japanese and International Economies,* Vol. 34, December, pp. 336-359.

Hara, Hiromi (2017), "The Effects of Minimum Wages on Training," *Labour Economics,* Vol. 47, August, pp. 149-162.

Higon, Dolores Anon, Jaime Gomez, and Pilar Vargas (2017), "Complementarities in Innovation Strategy: Do Intangibles Play a Role in Enhancing Firm Performance?" *Industrial and Corporate Change,* Vol. 26, No. 5, pp. 865–886.

Kodera, Nobuya and Yusuke Inoue (2018), "Characteristics and Effects of Firms' Human Capital Investment," Economic and Finance Analysis Discussion Paper, No. 18-2. (in Japanese)

Konings, Jozef and Stijn Vanormelingen (2015), "The Impact of Training on Productivity and Wages: Firm-Level Evidence," *Review of Economics and Statistics,* Vol. 97, No. 2, pp. 485–497.

Kurosawa, Masako, Fumio Ohtake, and Ken Ariga (2007), "Firm-Provided Training and Human Resources Management: Empirical Analysis on the Determinants and Effects," in Fumio Hayashi ed. *Causes of Economic Stagnation and Institutions*, Keiso Shobo Publisher, pp. 265–302. (in Japanese)

Kwon, Hyeog Ug, YoungGak Kim, and Tatsuji Makino (2012), "Determinants and Impact of Training in Japanese Firms: An Empirical Analysis Based on the Basic Survey of Human Resources Development," RIETI Discussion Paper, 12-J-013. (in Japanese)

Leuven, Edwin (2005), "The Economics of Private Sector Training: A Survey of the Literature," *Journal of Economic Surveys,* Vol. 19, No. 1, pp. 91–111.

Lynch, Lisa M. (1992), "Private-Sector Training and the Earnings of Young Workers," *American Economic Review*, Vol. 82, No. 1, pp. 299–312.

Melero, Eduardo (2010), "Training and Promotion: Allocation of Skills or Incentives?" *Industrial Relations,* Vol. 49, No. 4, pp. 640–667.

Miyagawa, Tsutomu, Yumi Nishioka, Atsushi Kawakami, and Kazuma Edamura (2011), "Human Resource Development and Productivity of Japanese Firms: An Empirical Analysis Using Unique Surveys on Human Resource Management," RIETI Discussion Paper, 11-J-035. (in Japanese)

Morikawa, Masayuki (2017), "Are Part-time Employees Underpaid or Overpaid? Evidence on

Productivity-Wage Gaps in Japan," RIETI Discussion Paper, 17-E-077.

Zwick, Thomas (2006), "The Impact of Training Intensity on Establishment Productivity," *Industrial Relations*, Vol. 45, No. 1, pp. 26–46.

Table 1. Variables and Summary Statistics

		Mean	Std. Dev. (overall)	Std. Dev. (within)	Number of observations	Number of firms
All industries	*ln(LP)*	2.0557	0.5768	0.1589	39,732	13,302
	ln(Training)	-3.8669	1.4213	0.4426	41,090	13,551
	ln(Tangible)	1.3182	1.7622	0.2278	40,769	13,469
	ln(R&D)	-0.7639	2.1619	0.3216	19,211	6,394
	ln(Soft)	-2.6829	1.6983	0.4872	31,258	10,896
	ln(Advertise)	-2.6358	2.0182	0.4006	36,128	12,069
	Part	0.1465	0.2192	0.0440	41,090	13,551
Manufacturing	*ln(LP)*	2.1025	0.5096	0.1654	17,720	5,905
	ln(Training)	-3.9182	1.3288	0.4337	18,138	5,972
	ln(Tangible)	2.0103	1.0513	0.1765	18,079	5,953
	ln(R&D)	-0.3760	1.9599	0.2813	13,176	4,348
	ln(Soft)	-2.7337	1.4557	0.4814	14,199	4,915
	ln(Advertise)	-3.0681	1.9446	0.4351	14,997	5,005
	Part	0.1062	0.1524	0.0377	18,138	5,972
Service	*ln(LP)*	1.9883	0.6086	0.1515	20,517	7,109
	ln(Training)	-3.8510	1.4924	0.4489	21,424	7,291
	ln(Tangible)	0.6746	1.9747	0.2596	21,162	7,226
	ln(R&D)	-1.6166	2.3566	0.3943	5,525	2,012
	ln(Soft)	-2.6727	1.8782	0.4857	15,858	5,738
	ln(Advertise)	-2.3110	2.0037	0.3655	19,737	6,792
	Part	0.1841	0.2608	0.0487	21,424	7,291

Note: With the exception of the share of part-time employees (*Part*), the figures are per employee value (million yen) transformed to logarithmic form.

Table 2. Distribution of the Training Stock Per Employee (Million Yen)

	Nobs.	Mean	Std. Dev.	p50	p75	p90	p95	≠0
All industries	90,125	0.0234	0.1599	0.0000	0.0206	0.0640	0.1061	45.6%
Manufacturing	40,958	0.0212	0.1660	0.0000	0.0183	0.0542	0.0878	44.3%
Service	46,233	0.0247	0.1580	0.0000	0.0222	0.0712	0.1187	46.3%

Note: The right end of the table indicates the percentages of firms with non-zero training stock.

Table 3. Determinants of Training Intensity

	(1) OLS		(2) Dprobit		(3) Tobit	
ln(Capital)	0.0063	***	0.0502	***	0.0230	***
	(0.0004)		(0.0012)		(0.0026)	
Firm age	0.0000		-0.0002	*	-0.0001	
	(0.0000)		(0.0001)		(0.0001)	
Part	-0.0189	***	-0.0825	***	-0.0541	***
	(0.0019)		(0.0099)		(0.0066)	
Industry*year FE	yes		yes		yes	
Adj. R^2, pseudo R^2	0.0084		0.0499		0.0815	
Nobs.	90,125		90,039		90,125	

Notes: OLS, probit, and tobit estimations with robust standard errors in parentheses. *** indicates statistical significance at the 1% level. The figures in (2) indicate marginal probability. The dependent variable in columns (1) and (3) is the training stock per employee (expressed in log form). The dependent variable in column (2) is whether a firm makes any training investment or not.

Table 4. Training Stock and Labor Productivity

	(1) All		(2) Manufacturing		(3) Service		(4) All		(5) Manufacturing		(6) Service	
ln(Training)	0.0220	***	0.0097	**	0.0321	***	0.0687	***	0.0506	***	0.0810	***
	(0.0030)		(0.0046)		(0.0039)		(0.0018)		(0.0026)		(0.0024)	
ln(Tangible)	0.0898	***	0.0871	***	0.0944	***	0.0931	***	0.1558	***	0.0679	***
	(0.0098)		(0.0165)		(0.0125)		(0.0021)		(0.0050)		(0.0025)	
Part	-0.3741	***	-0.1304	***	-0.5039	***	-0.8833	***	-0.7352	***	-0.9401	***
	(0.0379)		(0.0463)		(0.0542)		(0.0152)		(0.0253)		(0.0191)	
Firm FE	yes		yes		yes		no		no		no	
Industry*year FE	yes		yes		yes		yes		yes		yes	
R^2 (within), Adj. R^2	0.0692		0.047		0.0957		0.4492		0.3231		0.5109	
Nobs.	39,536		17,688		20,353		39,536		17,688		20,353	

Notes: Fixed-effects (columns (1)-(3)) and OLS ((4)-(6)) estimations with robust standard errors in parentheses. *** and ** indicate statistical significance at the 5% and 10% levels, respectively. The dependent variable is the log of value-added per employee.

Table 5. Intangible Assets and Labor Productivity

	(1) All	(2) Manufacturing	(3) Service	(4) All	(5) Manufacturing	(6) Service
ln(Training)	0.0184 ***	0.0085	0.0381 ***	0.0349 ***	0.0259 ***	0.0558 ***
	(0.0054)	(0.0066)	(0.0098)	(0.0027)	(0.0032)	(0.0052)
ln(Tangible)	0.0628 ***	0.0778 ***	0.0487 **	0.0858 ***	0.1503 ***	0.0381 ***
	(0.0155)	(0.0232)	(0.0218)	(0.0043)	(0.0069)	(0.0057)
ln(R&D)	0.0116 *	0.0055	0.0133	0.0485 ***	0.0595 ***	0.0286 ***
	(0.0063)	(0.0094)	(0.0084)	(0.0022)	(0.0028)	(0.0035)
ln(Soft)	0.0080 *	0.0039	0.0219 **	0.0593 ***	0.0483 ***	0.0674 ***
	(0.0046)	(0.0054)	(0.0089)	(0.0028)	(0.0034)	(0.0049)
ln(Advertise)	0.0142 **	0.0091	0.0310 **	0.0219 ***	0.0171 ***	0.0349 ***
	(0.0057)	(0.0061)	(0.0147)	(0.0022)	(0.0025)	(0.0045)
Part	-0.1863 **	-0.1095 *	-0.3654 **	-0.7781 ***	-0.6439 ***	-0.9318 ***
	(0.0634)	(0.0820)	(0.1605)	(0.0271)	(0.0306)	(0.0532)
Firm FE	yes	yes	yes	no	no	no
Industry*year FE	yes	yes	yes	yes	yes	yes
R^2 (within), Adj. R^2	0.084	0.0574	0.1394	0.4639	0.4286	0.5318
Nobs.	14,591	9,799	4,405	14,591	9,799	4,405

Notes: Fixed-effects (columns (1)-(3)) and OLS ((4)-(6)) estimations with robust standard errors in parentheses. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively. The dependent variable is the log of value-added per employee.

Table 6. Rate of Return to Training

	(1) All	(2) Manufacturing	(3) Service
A. Without opportunity costs adjustments			
Baseline (depreciation rate: 40%)	264%	108%	423%
Depreciation rate: 20%	267%	86%	477%
Replacing zero with 0.001	152%	87%	249%
B. Adjusted for opportunity costs			
Depreciation rate: 40%	21%	9%	34%
Depreciation rate: 20%	22%	7%	39%
Replacing zero with 0.001	12%	7%	20%

Notes: The figures in panel B are adjusted for the opportunity costs of Off-JT.

Table 7. Training Stock and Wages

	(1) All		(2) Manufacturing		(3) Service		(4) All		(5) Manufacturing		(6) Service	
ln(Training)	0.0223	***	0.0097	***	0.0317	***	0.0465	***	0.0347	***	0.0548	***
	(0.0028)		(0.0035)		(0.0043)		(0.0013)		(0.0019)		(0.0018)	
ln(Tangible)	0.0668	***	0.0593	***	0.0760	***	0.0253	***	0.0525	***	0.0166	***
	(0.0083)		(0.0129)		(0.0109)		(0.0013)		(0.0027)		(0.0016)	
Part	-0.3665	***	-0.1733	***	-0.4593	***	-0.8789	***	-0.6923	***	-0.9685	***
	(0.0375)		(0.0418)		(0.0531)		(0.0118)		(0.0205)		(0.0148)	
Firm FE	yes		yes		yes		no		no		no	
Industry*year FE	yes		yes		yes		yes		yes		yes	
R^2 (within), Adj. R^2	0.0616		0.0388		0.0829		0.4994		0.2922		0.5956	
Nobs.	40,769		18,079		21,162		40,769		18,079		21,162	

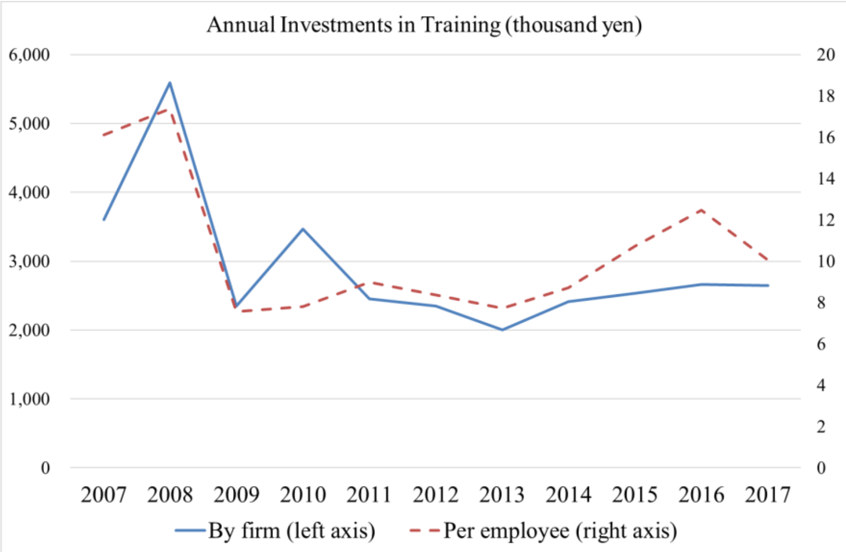
Notes: Fixed-effects (columns (1)-(3)) and OLS (columns (4)-(6)) estimations with robust standard errors in parentheses. *** indicates statistical significance at the 1% level. The dependent variable is the log of wages per employee.

Table 8. Intangible Assets and Wages

	(1) All		(2) Manufacturing		(3) Service		(4) All		(5) Manufacturing		(6) Service	
ln(Training)	0.0224	***	0.0108	**	0.0443	***	0.0260	***	0.0192	***	0.0407	***
	(0.0053)		(0.0049)		(0.0128)		(0.0021)		(0.0024)		(0.0040)	
ln(Tangible)	0.0594	***	0.0575	***	0.0626	***	0.0146	***	0.0334	***	0.0034	
	(0.0153)		(0.0159)		(0.0236)		(0.0024)		(0.0037)		(0.0031)	
ln(R&D)	0.0191	***	0.0049		0.0292	***	0.0312	***	0.0409	***	0.0149	***
	(0.0062)		(0.0070)		(0.0103)		(0.0016)		(0.0019)		(0.0028)	
ln(Soft)	0.0073	**	0.0055		0.0118		0.0293	***	0.0276	***	0.0271	***
	(0.0034)		(0.0035)		(0.0077)		(0.0019)		(0.0022)		(0.0034)	
ln(Advertise)	0.0157	**	0.0047		0.0494	**	0.0064	***	0.0066	***	0.0063	**
	(0.0077)		(0.0064)		(0.0246)		(0.0015)		(0.0018)		(0.0031)	
Part	-0.2362	***	-0.1621	***	-0.3201	*	-0.7589	***	-0.6357	***	-0.9842	***
	(0.0653)		(0.0560)		(0.1697)		(0.0209)		(0.0240)		(0.0415)	
Firm FE	yes		yes		yes		no		no		no	
Industry*year FE	yes		yes		yes		yes		yes		yes	
R^2 (within), Adj. R^2	0.0810		0.0433		0.1396		0.4570		0.3578		0.5863	
Nobs.	14,803		9,923		4,492		14,803		9,923		4,492	

Notes: Fixed-effects (columns (1)-(3)) and OLS (columns (4)-(6)) estimations with robust standard errors in parentheses. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively. The dependent variable is the log of wages per employee.

Figure 1. Recent Trend in Firms' Training Investments



Notes: Calculated from the published series of the Basic Survey of Human Resources Development (Ministry of Health, Labour, and Welfare). The training investments include Off-JT costs and pecuniary support for worker-initiated training. The calculation assumes that the mean sizes of firms with and without training expenditure are not different.

Appendix

Appendix Table A1. Summary Statistics of Training Stock Based on Alternative Assumptions

	Mean	Std. Dev. (overall)	Std. Dev. (within)	Number of observations	Number of firms
A. Depreciation rate=20%					
All industries	-3.4447	1.2921	0.3494	41,090	13,551
Manufacturing	-3.4916	1.1970	0.3439	18,138	5,972
Service	-3.4308	1.3650	0.3526	21,424	7,291
B. Trainging investment + 0.001					
All industries	-6.6476	2.7834	0.7746	90,125	26,668
Manufacturing	-6.6886	2.6768	0.7497	40,958	12,014
Service	-6.6476	2.8624	0.7871	46,233	14,241

Notes: The means and the standard deviations are expressed in logs. Training stock in Panel A assumes a 20% depreciation rate. Training stock in Panel B is calculated replacing zero training with 0.001(one thousand yen).

Appendix Table A2. Training Stock and Labor Productivity (Robustness)

	(1) All		(2) Manufacturing		(3) Service		(4) All		(5) Manufacturing		(6) Service	
ln(Training)	0.0324	***	0.0115	*	0.0503	***	0.0062	***	0.0037	**	0.0090	***
	(0.0040)		(0.0059)		(0.0054)		(0.0011)		(0.0017)		(0.0014)	
ln(Tangible)	0.0887	***	0.0871	***	0.0921	***	0.0957	***	0.0883	***	0.0947	***
	(0.0097)		(0.0165)		(0.0123)		(0.0071)		(0.0109)		(0.0086)	
Part	-0.3699	***	-0.1299	***	-0.4941	***	-0.3315	***	-0.1122	***	-0.4671	***
	(0.0375)		(0.0463)		(0.0532)		(0.0248)		(0.0298)		(0.0360)	
Firm FE	yes		yes		yes		yes		yes		yes	
Industry*year FE	yes		yes		yes		yes		yes		yes	
R^2 (within)	0.0705		0.047		0.1002		0.0542		0.0390		0.0722	
Nobs.	39,536		17,688		20,353		85,499		39,310		43,388	

Notes: Fixed-effects estimations with robust standard errors in parentheses. *** and ** indicate statistical significance at the 1% and 5% levels, respectively. The dependent variable is the log of value-added per employee. Columns (1)-(3) assume 20% depreciation rate for training stock. Columns (4)-(6) are based on the calculation replacing zero training with 0.001(one thousand yen).

Appendix Table A3. Intangible Assets and Labor Productivity (Robustness)

	(1) All	(2) Manufacturing	(3) Service	(4) All	(5) Manufacturing	(6) Service
ln(Training)	0.0205 ***	0.0062	0.0530 ***	0.0056 ***	0.0035 **	0.0081 ***
	(0.0065)	(0.0076)	(0.0126)	(0.0011)	(0.0018)	(0.0014)
ln(Tangible)	0.0626 ***	0.0781 ***	0.0476 **	0.0935 ***	0.0869 ***	0.0910 ***
	(0.0155)	(0.0231)	(0.0216)	(0.0071)	(0.0108)	(0.0083)
ln(R&D)	0.0116 *	0.0059	0.0126	0.0074 ***	0.0012	0.0147 ***
	(0.0063)	(0.0094)	(0.0083)	(0.0014)	(0.0018)	(0.0022)
ln(Soft)	0.0080 *	0.0039	0.0214 **	0.0019 ***	0.0017 **	0.0019 **
	(0.0046)	(0.0054)	(0.0088)	(0.0007)	(0.0011)	(0.0009)
ln(Advertise)	0.0144 **	0.0093	0.0309 **	0.0118 ***	0.0048 *	0.0216 ***
	(0.0057)	(0.0061)	(0.0145)	(0.0017)	(0.0025)	(0.0026)
Part	-0.1857 ***	-0.1094 *	-0.3560 **	-0.3245 ***	-0.1117 ***	-0.4483 ***
	(0.0634)	(0.0643)	(0.1589)	(0.0244)	(0.0298)	(0.0349)
Firm FE	yes	yes	yes	yes	yes	yes
Industry*year FE	yes	yes	yes	yes	yes	yes
R^2 (within)	0.0836	0.0571	0.1414	0.0566	0.0394	0.0800
Nobs.	14,591	9,799	4,405	85,492	39,305	43,386

Notes: Fixed-effects estimations with robust standard errors in parentheses. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively. The dependent variable is the log of value-added per employee. Columns (1)-(3) assume 20% depreciation rate for training stock. Columns (4)-(6) are based on the calculation replacing zero training with 0.001(one thousand yen).

Appendix Table A4. Training Stock and Wages (Robustness)

	(1) All	(2) Manufacturing	(3) Service	(4) All	(5) Manufacturing	(6) Service
ln(Training)	0.0347 ***	0.0152 ***	0.0500 ***	0.0068 ***	0.0046 ***	0.0090 ***
	(0.0036)	(0.0042)	(0.0056)	(0.0009)	(0.0013)	(0.0013)
ln(Tangible)	0.0655 ***	0.0589 ***	0.0738 ***	0.0728 ***	0.0675 ***	0.0780 ***
	(0.0082)	(0.0128)	(0.0106)	(0.0058)	(0.0086)	(0.0076)
Part	-0.3616 ***	-0.1726 ***	-0.4497 ***	-0.3422 ***	-0.1759 ***	-0.4399 ***
	(0.0371)	(0.0417)	(0.0523)	(0.0237)	(0.0251)	(0.0347)
Firm FE	yes	yes	yes	yes	yes	yes
Industry*year FE	yes	yes	yes	yes	yes	yes
R^2 (within)	0.0641	0.0394	0.0878	0.0478	0.0298	0.0644
Nobs.	40,769	18,079	21,162	89,328	40,752	45,655

Notes: Fixed-effects estimations with robust standard errors in parentheses. *** indicates statistical significance at the 1% level. The dependent variable is the log of wages per employee. Columns (1)-(3) assume 20% depreciation rate for training stock. Columns (4)-(6) are based on the calculation replacing zero training with 0.001(one thousand yen).

Appendix Table A5. Intangible Assets and Wages (Robustness)

	(1) All		(2) Manufacturing		(3) Service		(4) All		(5) Manufacturing		(6) Service	
ln(Training)	0.0293	***	0.0147	**	0.0587	***	0.0062	***	0.0043	***	0.0081	***
	(0.0062)		(0.0058)		(0.0145)		(0.0009)		(0.0013)		(0.0013)	
ln(Tangible)	0.0590	***	0.0572	***	0.0615	***	0.0706	***	0.0664	***	0.0743	***
	(0.0153)		(0.0159)		(0.0235)		(0.0057)		(0.0086)		(0.0074)	
ln(R&D)	0.0188	***	0.0047		0.0285	***	0.0087	***	0.0030	*	0.0155	***
	(0.0062)		(0.0069)		(0.0102)		(0.0013)		(0.0015)		(0.0021)	
ln(Soft)	0.0072	**	0.0054		0.0114		0.0015	***	0.0011		0.0017	**
	(0.0034)		(0.0035)		(0.0077)		(0.0006)		(0.0009)		(0.0007)	
ln(Advertise)	0.0157	**	0.0047		0.0496	**	0.0132	***	0.0061	***	0.0217	***
	(0.0078)		(0.0064)		(0.0248)		(0.0015)		(0.0019)		(0.0025)	
Part	-0.2346	***	-0.1617	***	-0.3113	*	-0.3345	***	-0.1756	***	-0.4212	***
	(0.0651)		(0.0559)		(0.1678)		(0.0234)		(0.0251)		(0.0337)	
Firm FE	yes		yes		yes		yes		yes		yes	
Industry*year FE	yes		yes		yes		yes		yes		yes	
R^2 (within)	0.0814		0.0435		0.1411		0.0520		0.0308		0.0741	
Nobs.	14,803		9,923		4,492		89,321		40,747		45,653	

Notes: Fixed-effects estimations with robust standard errors in parentheses. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively. The dependent variable is the log of wages per employee. Columns (1)-(3) assume 20% depreciation rate for training stock. Columns (4)-(6) are based on the calculation replacing zero training with 0.001(one thousand yen).