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# Decreasing Wage Returns to Human Capital: Analysis of Wage and Job Experience Using Micro Data of Workers

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# DECREASING WAGE RETURNS TO HUMAN CAPITAL

## Analysis of Wage and Job Experience Using Micro Data of Workers[*]

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Abstract

Recent literature reports a decrease in wage returns to skills since the 2000s. This paper contributes additional evidence that this trend is also occurring with skills that accumulate through job experience. We use micro data of Japanese workers to analyze this phenomenon by taking advantage of unique Japanese employment practices that emphasize skills acquired through tenure and on-the-job training as important human capital. We find that (1) wage returns to job experience have decreased from the 2000s to the 2010s and (2) decomposing the human capital into general and firm-specific, the returns to both have decreased. We also examine whether the recent trend of firms extending retirement age contributes to the decrease in returns, and we find that its impact has been marginal.

JEL Classification: J20; J24; J26; J30; O33

Keywords: Wage Returns; Skills; On-The-Job Training; General Human Capital; Firm-Specific Human Capital

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# I. INTRODUCTION

A huge amount of attention among economists has been paid to the association between workers' skills and wages over recent decades. One of the most prominent observations among the studies is that the complementarity between technological change and highly-skilled labor led to a growing demand for skills since the 1970s; skill-biased technological change (SBTC) (Katz and Murphy 1992, Acemoglu and Autor 2011, etc.).

However, recent studies observe there has been a change in this trend since the 2000s: the demand and thus returns to skills that are at the upper tail of distribution have turned to decrease. For example, the growth of the number of jobs that require high skills has slowed since the 2000s (Acemoglu and Autor 2011 and Beaudry et al. 2016). In terms of wage returns to skills, Castex and Dechter (2014) report the returns to cognitive skills are substantially lower in the 2000s than in the 1980s.

Another important type of skills which have been missing in this discussion is those that accumulate through job experience. Since the seminal work by Becker (1964), skills obtained through job experience are recognized as human capital because those skills enable workers to achieve higher productivity, thus delivering a positive association with workers' payoff.

The aim of this paper is to add another stylized fact — that the decrease in returns has also occurred with the human capital that accumulates through job experience. To the best of our knowledge, there are few papers analyzing the recent trend in returns to such human capital while other papers mainly focus on cognitive skills such as test scores. Given that the technological progress is skill-biased, our finding supports the recent observation that there is a shift in the types of skills demanded, as Deming (2017) argues returns to social skills that cannot be substituted by technology are increasing instead by enabling workers to reduce the cost of coordination and trade tasks according to their comparative advantage.

In this respect, Japan is a suitable arena for our analysis. Japan is known for its unique employment practice characterized by "lifetime employment;" where firms employ school graduates and promise employment until retirement age. In this practice, firms emphasize providing on-the-job training to their employees, and employees acquire a large part of their skills through job experience. The lifetime employment system and accumulation of "firm-specific" human capital among workers are known as major reasons for the Japanese economy's rapid growth until the 1980s.

Reflecting this context, there are rich series of studies analyzing the returns to human capital that we focus on. Especially after the 1980s, many papers assessed the steepness of the age-wage profile of Japanese workers (Hashimoto and Raisian 1985, Mincer and Higuchi 1988 etc.). The steep age-wage and tenure-wage profiles are still reported in the recent literature (Hamaaki et al. 2012, and Yamada and Kawaguchi 2015). In this paper, we analyze the micro data of Japanese workers from the *Basic Survey on Wage Structure* and try to observe the chronological change in returns to human capital that accumulates through job experience. Along with the line of recent literature, we find that the returns to such human capital have been decreasing over time in the period from the 2000s to the 2010s.

Moreover, we try to distinguish whether the decrease in returns has occurred with "general" or "firm-specific" human capital using Becker's definition. To do this, we use panel data of Japanese individuals from the *Japan Household Panel Survey* (JHPS/KHPS) with the two-stage estimation methodology used by Topel (1991) and find that such a decrease has occurred with both types of human capital.

In the analysis mentioned above, we assume that the wage is determined based on the workers' productivity. On the other hand, there is another widely accepted model that explains the positive association between wage returns and tenure without assuming the improvement of productivity which workers gain with job experience. Lazear (1979) proposed an explanation based on a principal-agent model where firms could provide a disincentive to shirk by paying workers less than their marginal product when young and more than their marginal product when they are old. The existence of the mandatory retirement age backs up this model, because it is not optimal for firms to pay more than a worker's marginal product forever. With this model in mind, we tested whether the recent trend of extending the retirement age of workers in reaction to an aging workforce (OECD 2017) led to the flattening of the tenure-wage profile. We finally find that such an effect exists, but explains only a marginal part of the observed decrease in returns.

The remainder of this paper is organized as follows. Section 2 explains the data for our analysis. Section 3 presents the estimated chronological change in returns to human capital associated with job experience. Section 4 reports the change in returns separately estimated for "general" and "firm-specific" human capital using a panel data of Japanese workers. Section 5 presents how much the decrease in the returns can be explained by the recent trend of extending retirement ages. Section 6 concludes.

## II. DATA

In this paper, we use two sets of micro data — the *Basic Survey on Wage Structure* and the *Japan Household Panel Survey*.

### (1) Basic Survey on Wage Structure

The *Basic Survey on Wage Structure* (hereafter BSWS) is an annual survey which aims to capture the wage structure of Japanese workers in main industries, and is selected as one of the Fundamental Statistics according to the Statistics Act. The sample of BSWS is designed to comprehensively cover the structure of all establishments in Japan with more than five employees. As for the survey of 2017, the number of establishments sampled amounts to about 78,000 and workers about 1.67 million. BSWS collects information about the establishment itself (i.e. industry, location and number of employees etc.) and about a random sample of workers from the establishment picked from the payroll (i.e. age, gender, wage, tenure, education, occupation, worked days and hours etc.). Micro data of the survey is accessible with the permission of the Ministry of Health, Labour and Welfare of Japan.

### (2) Japan Household Panel Survey

The *Japan Household Panel Survey* (hereafter JHPS/KHPS) is panel data of Japanese individuals provided by the Keio University Panel Data Research Center. JHPS/KHPS was previously two different surveys, the *Keio Household Panel Survey* and the *Japan Household Panel Survey*. They were launched in 2004 and 2009 respectively, but they are currently available as merged panel data.

JHPS/KHPS has a large sample size. As for the survey of 2016, the target is about 5,000 individuals nationwide. The survey is a comprehensive questionnaire of individual attributes such as gender, age, household structure, level of education, employment status, use of living hours, and source of income.

## III. ESTIMATION OF RETURNS TO HUMAN CAPITAL

We employ the standard Mincer equation and observe the coefficients of workers' tenure with their employers.

### (1) Estimation method

We use the following specification of the standard Mincer equation (Mincer 1974, Murphy and Welch 1990).

$$ln(wage_i) = constant + \sum_{s=1}^{4}(\beta_s * {tenure_i}^s) + \sum_j \gamma_j * dummy_{ij} + \varepsilon_i \qquad (1)$$

where $wage$ denotes scheduled cash earnings and $tenure$ denotes years of working at the current firm for worker $i$. This equation includes dummy variables for five categories (level of education, occupation, industry, firm size and prefecture) to control for workers' characteristics. More details of the variables are described in Appendix 1.

The target workers are under 59 who are "lifetime" employees — those workers who have been at the same firms since graduating from school. In BSWS, about one-third of fulltime employees are lifetime employees reflecting the Japanese employment practice. We are able to distinguish life-time employees because BSWS asks age, tenure and level of education. The age limitation is due to the fact that there is discontinuity in age-wage profile at the age of 60. This is because in the "lifetime" employment system, if a worker continues to work after the legal minimum retirement age of 60, a certain proportion of their wage is cut as a practice. The exclusion of workers aged over 60 in estimating wage returns to Japanese workers is common in the previous literature, such as Yamada and Kawaguchi (2015). Throughout this paper, our target is both genders. The estimate results for each gender are shown in Appendix 2 in which we find almost the same results for both genders.

The whole data period of estimation spans from 2005 to 2017, and it is divided into 2005-2008, 2009-2012 and 2013-2017 for pooled estimations.

### (2) Estimation result

Table 1 shows the estimation result of equation (1). The coefficients for $tenure$ are mostly statistically significant. The coefficient of tenure to the first power steadily decreases over time from 3.4 percent in 2005-2008 to 2.9 percent in 2013-2017; the returns to human capital accumulated through job experience still exist because the tenure of workers is positively associated with wage, but wage does not grow as much as it used to for each additional year of job experience.

Table 1. Estimated wage returns to tenure

Dependent variable: natural log of scheduled cash earnings

| Period | 2005-2008 | 2009-2012 | 2013-2017 |
|---|---|---|---|
| Tenure | 0.034 *** | 0.032 *** | 0.029 *** |
| | (0.001) | (0.001) | (0.001) |
| $Tenure^2$ ($\times 10^2$) | -0.007 | 0.005 | 0.005 |
| | (0.008) | (0.009) | (0.007) |
| $Tenure^3$ ($\times 10^3$) | -0.019 *** | -0.023 *** | -0.019 *** |
| | (0.003) | (0.004) | (0.003) |
| $Tenure^4$ ($\times 10^4$) | 0.003 *** | 0.003 *** | 0.002 *** |
| | (0.000) | (0.000) | (0.000) |
| Gender | -0.096 *** | -0.082 *** | -0.081 *** |
| | (0.002) | (0.002) | (0.002) |
| College | 0.155 *** | 0.150 *** | 0.135 *** |
| | (0.002) | (0.002) | (0.001) |
| Constant | 7.993 *** | 8.065 *** | 8.199 *** |
| | (0.018) | (0.031) | (0.031) |
| Observations | 455,970 | 437,594 | 595,905 |
| Adjusted $R^2$ | 0.830 | 0.826 | 0.816 |

Note: *** denotes statistical significance at the 1 percent level. In addition to the independent variables shown in the table, we include dummy variables on industry, occupation, firm size and prefecture. Values in parentheses indicate robust standard errors.

Table 2 reports the tenure-wage profile calculated from the estimate result in Table 1. It shows that, standardizing the wage of workers with zero tenure at 100, the accumulated wage returns to workers with 30 years of tenure decreases from 67.6 in 2005-2008 to 60.6 in 2013-2017.

Table 2. Tenure-wage profiles

| Accumulated returns to tenure at | (1) 2005-2008 | (2) 2009-2012 | (3) 2013-2017 |
|---|---|---|---|
| 1 year | 3.4 | 3.2 | 2.9 |
| 5 years | 16.7 | 16.0 | 14.5 |
| 10 years | 31.9 | 30.7 | 28.0 |
| 20 years | 54.9 | 53.2 | 49.1 |
| 30 years | 67.6 | 65.2 | 60.6 |

Note: The figures indicate additional predicted scheduled cash earnings with various years of tenure when the level of regular cash earnings at zero years of tenure is standardized at 100.

Another implication is that the decrease in returns to human capital has occurred regardless of the business cycle. From 2009 to 2012 the output gap estimated by the Bank of Japan is significantly negative; from 2005 to 2008 and 2013 to 2017 it is positive or around zero, as Japan's economy has experienced different growth paces. Past studies specific to the Japanese labor market argue that the excess workers during the slow economic growth period led to the flattening of the age-wage profile in the 1990s and 2000s (Hamaaki et al 2012). But we see a decrease in returns to job experience also in the period of transition from recession to economic recovery and following expansion (from 2009-2012 to 2013-2017). This implies that the decrease in returns is related to, at least in part, structural phenomena.

## IV. General or Firm-Specific Human Capital?

In the previous section, we estimated the returns to whole human capital that accumulates through one year of job experience. On this point, previous studies report such human capital can be divided into several types. The most widely accepted notion is Becker's (1964) definition that distinguishes human capital accumulated through job experience into general human capital — the skills portable to other firms — and firm-specific human capital — the skills only applicable to working with the current employer. The estimates in Section 3 are the aggregate of returns to both types of human capital because the observations are limited to workers who only work for the same firm in their professional career.

In this section, we assess which human capital causes the observed decrease in the returns. One way to distinguish these types of human capital is the two-stage estimation conducted by Topel (1991) using panel data of workers. Here, we use JHPS/KHPS in applying Topel's method to Japanese workers.

## (1) Estimation method

A standard Mincer equation involves the upward bias on the estimate of tenure coefficient because the higher the matching quality between workers and firms, the longer the tenure and higher the wage tends to be. The two-stage estimation methodology proposed by Topel (1991) is subject to less estimation bias generated from quality of matching. Another important merit of using this method is the model's robustness to distinguish between returns to years of general job experience and those to tenure in a specific firm.

Following Topel (1991), wage determination can be modeled as follows:

$$ln(wage_{it}) = constant + \beta_1 exp_{it} + \beta_2 tenure_{it} + u_i + \varphi_{it} + \varepsilon_{it} \qquad (2)$$

where $exp$ denotes total number of years of job experience after graduating school, $tenure$ denotes years of working at the current firm, $u$ denotes worker's affiliate associated with wage (such as the level of education), $\varphi$ denotes matching quality of the firm and the worker, and $\varepsilon$ denotes stochastic component.

We target workers under 59 and exclude part-time and contractual workers. Due to the characteristics of the estimation method subsequently explained, the target workers are those who did not change jobs in each year in the first stage estimation, and the job changers are added in in the second stage estimation.

For workers who did not change jobs, working for one year increases both $exp$ and $tenure$ by one. Here, we assume matching quality does not vary with time ($\varphi_{it} = \varphi_i$) for a specific firm-employee pair. Taking the first difference of equation (2) leads to the following equation, where $u$ and $\varphi$ are eliminated.

$$\Delta ln(wage_{it}) = \beta_1 + \beta_2 + \Delta\varepsilon_{it} \,. \tag{3}$$

In the first stage, we estimate the equation (3) using panel data of workers who continued to work at the same firm, and we are able to obtain the estimate of $\beta_1 + \beta_2$.

Then, by expanding the observations to all the target workers including job changers who worked with different employers from the previous year, the wage equation can be written as follows:

$$ln(wage_{it}) = constant + \beta_1 exp_i^0 + (\beta_1 + \beta_2)tenure_{it} + u_i + \varphi_{it} + \varepsilon_{it} \tag{4}$$

where $exp^0$ denotes the years of job experience at the time when the worker changed job and started to work with the current employer. For lifetime employees who have not changed their employers throughout their professional career, $exp^0$ is zero. The equation (4) can be rewritten as follows:

$$ln(wage_{it}) - (\beta_1 + \beta_2)tenure_{it} = constant + \beta_1 exp_i^0 + u_i + \varphi_{it} + \varepsilon_{it} \,. \tag{5}$$

In the second stage, we substitute $\beta_1 + \beta_2$ in the left hand side to its estimate in the first stage and estimate $\beta_1$. Finally, by subtracting the estimate of $\beta_1$ from that of $\beta_1 + \beta_2$, we are able to obtain the estimate of $\beta_2$.

## (2) Estimation results

Table 3 shows the estimation results of the first stage[1]. The estimates are statistically significant at the 1 percent level for both periods. The coefficients show the average one-year wage growth for workers who did not change their jobs. Thus, this can be interpreted as the sum of returns to general and firm-specific human capital. This result shows that the returns have decreased from 2.5 percent in the 2000s to 1.5 percent in the 2010s, which is consistent with the result of Section 3.

Table 3. Result of first stage estimation

Dependent variable:
change in natural log of hourly wage

| Period | 2004-2009 | 2010-2015 |
|---|---|---|
| $\beta_1+\beta_2$ | 0.025 *** | 0.015 *** |
| | (0.003) | (0.002) |
| Observations | 4,247 | 6,189 |

Note: *** denotes statistical significance at the 1 percent level.
Values in parentheses indicate robust standard errors.

Table 4 reports the results of the second stage estimation on the returns to general job experience. The result in column (3) shows that the returns to general job experience have decreased from 0.7 percent in the 2000s to 0.4 percent in the 2010s.

[1] Following Topel (1991), we firstly estimated a quartic specification, but found that these quartic estimates were statistically insignificant. Based on a general-to-specific principle, we dropped insignificant terms and finally ended up with a linear specification. The outcome is consistent with the observation in the previous section. Here, linear results still match our interest in decomposing the decreasing wage returns already found in the previous section with a quartic specification.

Table 4. Result of second stage estimation

Dependent variable: tenure-adjusted natural log of hourly wage

Period: 2004-2009

| Model | (1) | | (2) | | (3) | |
|---|---|---|---|---|---|---|
| $\beta_1$ | 0.003 | * | 0.006 | *** | 0.007 | *** |
| | (0.002) | | (0.002) | | (0.002) | |
| Gender | -0.326 | *** | -0.302 | *** | -0.304 | *** |
| | (0.020) | | (0.019) | | (0.019) | |
| College | | | 0.233 | *** | 0.236 | *** |
| | | | (0.016) | | (0.016) | |
| Graduate school | | | 0.415 | *** | 0.413 | *** |
| | | | (-0.039) | | (-0.041) | |
| Other dummies | | | | | | |
| Job status | No | | No | | Yes | |
| Union membership | No | | No | | Yes | |
| Constant | -0.262 | *** | -0.394 | *** | -0.413 | *** |
| | (0.06) | | (0.067) | | (0.067) | |
| Observations | 3,052 | | 3,052 | | 3,052 | |
| Adjusted $R^2$ | 0.132 | | 0.267 | | 0.272 | |

Period: 2010-2015

| | | | | | | |
|---|---|---|---|---|---|---|
| $\beta_1$ | -0.002 | | 0.002 | | 0.004 | ** |
| | (0.002) | | (0.002) | | (0.002) | |
| Gender | -0.354 | *** | -0.351 | *** | -0.355 | *** |
| | (0.025) | | (0.023) | | (0.019) | |
| College | | | 0.210 | *** | 0.216 | *** |
| | | | (0.019) | | (0.019) | |
| Graduate school | | | 0.400 | *** | 0.416 | *** |
| | | | (0.036) | | (0.036) | |
| Other dummies | | | | | | |
| Job status | No | | No | | Yes | |
| Union membership | No | | No | | Yes | |
| Constant | -0.054 | | -0.179 | *** | -0.220 | *** |
| | (0.055) | | (0.060) | | (0.063) | |
| Observations | 1,754 | | 1,754 | | 1,754 | |
| Adjusted $R^2$ | 0.152 | | 0.264 | | 0.289 | |

Note: ***, ** and * denote statistical significance at the 1, 5 and 10 percent levels, respectively. Values in parentheses indicate standard errors computed using the bootstrap (100 replications).

Table 5 reports the separate returns to general and firm-specific human capital. Column (1) and (2) show the estimates of $\beta_1 + \beta_2$ in Table 3 and $\beta_1$ in Table 4, respectively. By subtracting returns in column (2) from those in column (1), we are able to calculate the returns to firm-specific human capital shown in column (3). The result shows both returns have decreased to nearly the half from the 2000s to the 2010s; returns to general human capital decreased from 0.7 percent to 0.4 percent while returns to firm-specific human capital decreased from 1.8 percent to 1.1 percent.

Table 5. Summary of returns to human capital

| | (1)<br>Combined returns<br>$\beta_1$+$\beta_2$ | (2)<br>General<br>$\beta_1$ | (3)<br>Firm-specific<br>$\beta_2$ |
|---|---|---|---|
| 2004-2009 (A) | 0.025 *** | 0.007 *** | 0.018 *** |
| | (0.003) | (0.002) | (0.004) |
| 2010-2015 (B) | 0.015 *** | 0.004 ** | 0.011 *** |
| | (0.002) | (0.002) | (0.003) |
| Change (B-A) | -0.010 | -0.003 | -0.007 |

Note: *** and ** denote statistical significance at the 1 and 5 percent levels, respectively. Values in parentheses in column (1) indicate robust standard errors and column (2) and (3) are standard errors computed using the bootstrap (100 replications).

This result indicates that, with Topel's method mitigating the bias from matching quality, the decreasing returns to human capital are also observable using the workers' panel data as observed in Section 3. Moreover, we find that the decrease in returns have occurred with both general and firm-specific human capital.

Although having decreased, firm-specific human capital still shows importance as one-year accumulation of firm-specific human capital generates 1.1 percent of wage growth in the 2010s, which is more than double the returns to general human capital. Notably, recent literature suggests what is thought to be firm-specific human capital might not be purely specific to firms. Neal (1995) and Parent (2000) argue that the source of the returns to tenure is more related to industries rather than firms. Along the same lines, Kambourov and Manovskii (2009) report that tenure with the current employer or industry explains little on wage growth when controlling for occupational experience. Gathmann and Schönberg (2010) argue that task-specific human capital is an important source of wage growth using data of German workers.

In this respect, if the firm-specific human capital of workers is actually portable to other firms in the same area of industry, occupation or task, we would have found higher returns to general human capital ($\beta_1$) and lower returns to firm-specific human capital ($\beta_2$). The larger estimated returns in $\beta_2$ implies two possibilities. One simple possibility is that the job changers targeted in this estimation moved to totally different jobs with regards to industry, occupation or task. The other possibility is that firm-specific human capital still generates significant wage returns. Lazear (2009) proposes the "skill-weights approach" which views firm-specificity as each firm's idiosyncratic weights of the usage of different skills. Wasmer (2006) proposes a model that explains higher returns to firm-specific human capital than those to general human capital when the job finding rates are low. While those possibilities are not tested in this paper, the significance of firm-specific human capital is a rich avenue for future work.

## V. Effect of Retirement Age Extension

In the previous sections, we assumed that returns to human capital increase with job experience because human capital improves the marginal productivity of a worker through accumulation of skills. While this is a plausible assumption, there is another widely accepted notion why wage returns increase with job experience. Lazear (1979) proposes an explanation based on a principal-agent model where firms provide a disincentive to shirk by paying workers less than their marginal product when young and more than their marginal product when old. This endorses why firms usually set retirement ages in the real world because it is not optimal for firms to pay more than a worker's marginal product forever.

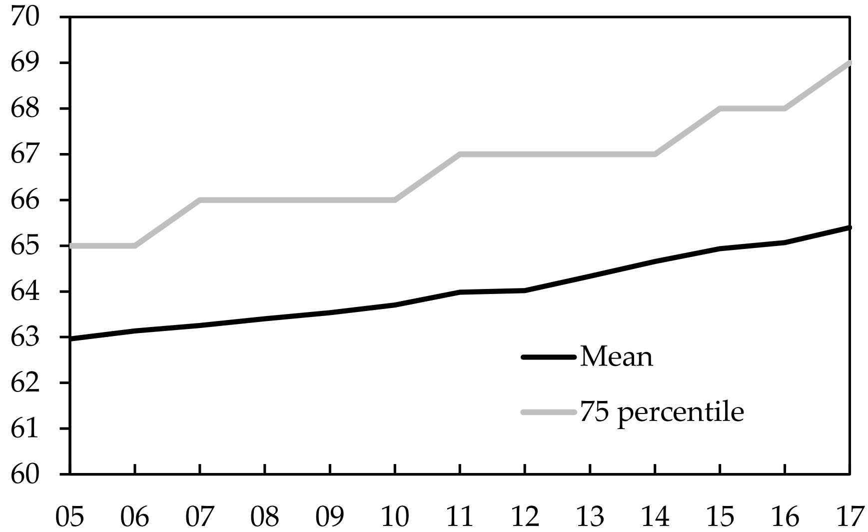
We care the possibility that the recent extension of retirement age of an aging of workforce (OECD 2017) has led to the flattening of the tenure-wage profile. We employ the estimation method used by Clark and Ogawa (1992) which tests Lazear's hypothesis by investigating the impact of change in firms' mandatory retirement ages on the tenure-wage profile.

Using BSWS micro data, we estimate Mincer equation with the following specification that incorporates variables for the retirement ages of each establishment.

$$\begin{aligned} ln(wage_{ik}) = constant + \sum_{s=1}^{4}[\beta_{1s} * tenure_i{}^s + \beta_{2s}(retire_{ik} * tenure_i{}^s)] \\ +\beta_3 * retire_{ik} + \sum_j \gamma_j * dummy_{ij} + \varepsilon_i \end{aligned} \tag{6}$$

where $tenure$ denotes years of working at the current firm, $retire$ denotes the proxy for retirement ages for a worker $i$ in establishment $k$. Dummy variables in equation (1) are also included. Since information on exact retirement ages set by firms is not available from the BSWS data, we alternatively use the age of the oldest worker sampled in each firm as a proxy for the retirement age. Figure 1 shows that the mean proxy retirement age has risen rapidly from 63.0 in 2013 to 65.4 in 2017.

Figure 1. Change in retirement age




Note: The figure shows the chronological change of retirement ages used for the estimation of the equation (6).

Table 6 reports that the coefficients of the interaction terms between the retirement age and tenure are statistically significant from 2009 to 2012 and from 2013 to 2017. Thus, we are able to see that the extension of retirement age has a downward effect on the tenure-wage profile.

Table 6. Estimation result on effect of retirement age

| Dependent variable: natural log of scheduled cash earnings | | | |
|---|---|---|---|
| | (1) | (2) | (3) |
| Period | 2005-2008 | 2009-2012 | 2013-2017 |
| Tenure | 0.049 *** | 0.088 *** | 0.076 *** |
| | (0.013) | (0.014) | (0.010) |
| Tenure$^2$ (×10$^2$) | 0.121 | -0.405 *** | -0.188 |
| | (0.145) | (0.154) | (0.117) |
| Tenure$^3$ (×10$^3$) | -0.096 | 0.114 * | -0.004 |
| | (0.059) | (0.061) | (0.049) |
| Tenure$^4$ (×10$^4$) | 0.013 | -0.013 * | 0.006 |
| | (0.008) | (0.008) | (0.007) |
| Interaction (Retirement age×tenure) | -0.0002 | -0.0009 *** | -0.0007 *** |
| | (0.0002) | (0.0002) | (0.0002) |
| Interaction2 (Retirement age×tenure$^2$) (×10$^2$) | -0.0021 | 0.0065 *** | 0.0030 |
| | (0.0023) | (0.0024) | (0.0018) |
| Interaction3 (Retirement age×tenure$^3$) (×10$^3$) | 0.0013 | -0.0022 ** | -0.0002 |
| | (0.0010) | (0.0010) | (0.0008) |
| Interaction4 (Retirement age×tenure$^4$) (×10$^4$) | -0.0002 | 0.0003 ** | -0.0001 |
| | (0.0001) | (0.0001) | (0.0001) |
| Retirement age | 0.0018 *** | 0.0025 *** | 0.0022 *** |
| | (0.0004) | (0.0005) | (0.0003) |
| Gender | -0.096 *** | -0.083 *** | -0.081 *** |
| | (0.002) | (0.002) | (0.002) |
| College | 0.156 *** | 0.151 *** | 0.136 *** |
| | (0.002) | (0.002) | (0.001) |
| Constant | 7.874 *** | 7.903 *** | 8.051 *** |
| | (0.032) | (0.043) | (0.038) |
| Dummy variables | Yes | Yes | Yes |
| Observations | 455,970 | 437,594 | 595,905 |
| Adjusted R-squared | 0.830 | 0.827 | 0.816 |

Note: ***, ** and * denote statistical significance at the 1, 5 and 10 percent levels, respectively. Values in parentheses indicate robust standard errors. In addition to the independent variables shown in the table, we include dummy variables on occupation, industry, firm size and prefecture.

Using this result, we compare the tenure-wage profiles with and without the effect of retirement age in Table 7 from 2013 to 2017, the period when the pace of the rising retirement age is the most rapid. The values in the table are additional wages at various years of tenure when wages at zero years of tenure are standardized at 100. The difference in column (2) and (3) indicates the decline of tenure-wage profile that is accountable to the extended retirement age, which marginally explains the actual decline in tenure-wage profile observed from 2013 to 2017 shown in the difference between column (1) and (3). The results in Table 6 and 7 imply that enhanced employment of elderly workers in line with Lazear's hypothesis is statistically significant, but not the main reason for the decrease in the returns to job experience.

Table 7. Tenure-wage profiles and impact of extending retirement age

| Accumulated returns to tenure at | (1) 2013 | (2) 2017 Without estimated effect of extending retiremet age | (3) 2017 |
|---|---|---|---|
| 1 year | 3.0 | 2.8 | 2.7 |
| 5 years | 14.9 | 14.0 | 13.4 |
| 10 years | 28.8 | 27.0 | 25.9 |
| 20 years | 50.3 | 46.8 | 45.6 |
| 30 years | 61.7 | 57.6 | 56.5 |

Note: The figures indicate additional predicted scheduled cash earnings with various years of tenure when the level of regular cash earnings at zero years of tenure is standardized at 100.

## VI. CONCLUSION

This paper investigates the wage returns to human capital that accumulates through job experience using micro data of Japanese workers. We find that such returns have decreased between the periods of the 2000s to the 2010s. We test whether the decrease has occurred with general human capital or firm-specific human capital and find that returns to both have decreased. We assess whether this decrease is due to the principal-agent model, that is, the effect of the recent trend in extending the retirement age of workers through the model proposed by Lazear (1979). We find that this effect exists, but it does not have enough impact to explain the decline in returns to skills.

While our main contribution is to add a new stylized fact regarding the recent trend of returns to human capital with job experience, it remains unclear what has caused the decreasing trend. Beaudry et al. (2016) conjecture that cognitive skills were actively needed in the stage in which firms invested in new information technology related capital, but after that stage, those skills are needed simply to maintain the new capital. Castex and Dechter (2014) argue that the decreasing returns to ability reflect the slowing down of technological progress. These factors might affect the returns to human capital accumulated through job experience.

On the other hand, as Deming (2017) argues that social skills are increasing in their importance, there might be a shift in the types of skills needed by firms. In this regard, our results suggest that the connection between the on-the-job training and skills that improve productivity of firms might be weakening and different types of skill have increasing importance. In this respect, investigating what kind of shifts in demand and returns to the skills that accumulate through on-the-job training are an area for further research.

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## APPENDIX 1: DATA DESCRIPTION

The definitions of variables used for the estimation in this paper and summary statistics are shown in Table A-1.

Table A-1. Definitions of variables and summary statistics

BSWS Data

| | | Summary statistics (2005-2017) | | | |
|---|---|---|---|---|---|
| Variable | | Mean | Min | Max | S.D. |
| Scheduled cash earnings | Log of contractual earnings excluding overtime pay | 8.058 | 7.170 | 9.642 | 0.399 |
| Tenure | Years of seniority for the current firm | 14.641 | 0 | 41 | 11.211 |
| Retirement age | The age of the oldest worker in the establishment the worker is working for. | 62.435 | 60 | 77 | 3.317 |
| Gender | 1 if the worker is female | 0.224 | | | |
| College | 1 if attaining college or higher education (otherwise high school graduate) | 0.680 | | | |
| Other dummies | | | | | |
| Industry | Categorical variable for Japan Standard Industrial Classification | | | | |
| Occupation | Categorical variable for 129 occupations and 5 classes of position (director, section manager, chief, foreman and others) | | | | |
| Firm size | Categorical variable for the firm size of researched establishments (classified into 8 based on the number of employees) | | | | |
| Prefecture | Categorical variable for 47 Japanese prefectures where the reserearched establishments were located | | | | |

Note: Samples with calculated hourly wage below the legal minimum hourly wage are dropped. We then winsorized scheduled cash earnings at 1 and 99 percentile. Retirement age is calculated after winsorizing workers aged more than 60 at 99 percentile. The minimum retirement age is set to be 60 if the oldest worker in the establishment is below 60 as per the legal minimum retirement age in Japan.

JHPS/KHPS Data

| | | Summary statistics (2003-2015) | | | |
|---|---|---|---|---|---|
| Variable | | Mean | Min | Max | S.D. |
| Hourly wage | Log of contractual earnings divided by total hours worked. Contractual earnings are deflated for each year and gender by average wage of workers from BSWS. | 0.083 | -3.388 | 2.609 | 0.403 |
| Tenure | Years of seniority for the current firm | 16.939 | 1 | 45 | 9.729 |
| Gender | 1 if the worker is female | 0.186 | | | |
| College | 1 if attaining college education | 0.445 | | | |
| Graduate school | 1 if attaining graduate education | 0.047 | | | |
| Job status | Dummy variables for the worker's job change from previous year; | | | | |
| | 1 if continuous employment with no transfer | 0.887 | | | |
| | 1 if continuous employment with transfer | 0.068 | | | |
| | 1 if temporary transfer | 0.008 | | | |
| | 1 if job switch | 0.037 | | | |
| Union membership | 1 if union member | 0.336 | | | |

Note: We winsorized contractual earnings at 1 and 99 percentile before calculationg hourly wage.

## APPENDIX 2: ESTIMATION BY GENDER

Most papers analyzing the relationship between wage and job-experience among Japanese workers only use data for male workers because the number of female "lifetime" employees increased after the enforcement of the *Equal Employment Opportunity Law* in 1986 and the behavior of firms employing female workers has changed drastically since then. Although previous studies have focused on the male worker, we estimate workers of both genders together.

In this appendix, we replicate the estimate tables by each gender. Our main results — decreasing returns to skills accumulated through job experience and existing but marginal effect from the extension of retirement ages — are observable for both genders.

Table A2-1. Estimated wage returns to tenure (male)

Dependent variable: natural log of scheduled cash earnings

| Period | 2005-2008 | 2009-2012 | 2013-2017 |
|---|---|---|---|
| Tenure | 0.039 *** | 0.038 *** | 0.034 *** |
| | (0.001) | (0.001) | (0.001) |
| Tenure$^2$ ($\times 10^2$) | -0.033 *** | -0.025 ** | -0.019 ** |
| | (0.009) | (0.011) | (0.009) |
| Tenure$^3$ ($\times 10^3$) | -0.013 *** | -0.016 *** | -0.015 *** |
| | (0.004) | (0.004) | (0.003) |
| Tenure$^4$ ($\times 10^4$) | 0.002 *** | 0.003 *** | 0.002 *** |
| | (0.000) | (0.001) | (0.000) |
| College | 0.149 *** | 0.145 *** | 0.132 *** |
| | (0.002) | (0.002) | (0.002) |
| Constant | 7.985 *** | 8.053 *** | 8.187 *** |
| | (0.018) | (0.033) | (0.033) |
| Observations | 394,229 | 373,105 | 497,125 |
| Adjusted $R^2$ | 0.811 | 0.811 | 0.801 |

Note: This table corresponds to Table 1 in the main article. *** and ** denote statistical significance at the 1 and 5 percent levels, respectively. In addition to the independent variables shown in the table, we include dummy variables on industry, occupation, firm size and prefecture.

Table A2-2. Tenure-wage profiles (male)

| Accumulated returns to tenure at | (1) 2005-2008 | (2) 2009-2012 | (3) 2013-2017 |
|---|---|---|---|
| 1 year | 3.8 | 3.7 | 3.4 |
| 5 years | 18.4 | 17.9 | 16.4 |
| 10 years | 34.4 | 33.7 | 31.0 |
| 20 years | 57.6 | 56.4 | 52.4 |
| 30 years | 70.3 | 68.1 | 63.6 |

Note: This table corresponds to Table 2 in the main article. The figures indicate additional predicted scheduled cash earnings with various years of tenure when the level of regular cash earnings at zero years of tenure is standardized at 100.

Table A2-3. Estimated wage returns to tenure (female)

Dependent variable: natural log of scheduled cash earnings

| Period | 2005-2008 | 2009-2012 | 2013-2017 |
|---|---|---|---|
| Tenure | 0.036 *** | 0.034 *** | 0.032 *** |
| | (0.001) | (0.001) | (0.001) |
| $Tenure^2$ ($\times 10^2$) | -0.114 *** | -0.121 *** | -0.128 *** |
| | (0.020) | (0.019) | (0.015) |
| $Tenure^3$ ($\times 10^3$) | 0.034 *** | 0.040 *** | 0.045 *** |
| | (0.009) | (0.008) | (0.007) |
| $Tenure^4$ ($\times 10^4$) | -0.004 *** | -0.005 *** | -0.006 *** |
| | (0.001) | (0.001) | (0.001) |
| College | 0.171 *** | 0.163 *** | 0.142 *** |
| | (0.004) | (0.004) | (0.003) |
| Constant | 8.052 *** | 7.956 *** | 8.216 *** |
| | (0.036) | (0.026) | (0.030) |
| Observations | 62,116 | 64,944 | 99,252 |
| Adjusted $R^2$ | 0.751 | 0.745 | 0.729 |

Note: This table corresponds to Table 1 in the main article. *** denotes statistical significance at the 1 percent level. In addition to the independent variables shown in the table, we include dummy variables on industry, occupation, firm size and prefecture.

Table A2-4. Tenure-wage profiles (female)

| Accumulated returns to tenure at | (1) 2005-2008 | (2) 2009-2012 | (3) 2013-2017 |
|---|---|---|---|
| 1 year | 3.4 | 3.3 | 3.1 |
| 5 years | 15.3 | 14.4 | 13.3 |
| 10 years | 27.1 | 25.2 | 23.0 |
| 20 years | 45.6 | 42.7 | 38.8 |
| 30 years | 60.2 | 57.1 | 52.5 |

Note: This table corresponds to Table 2 in the main article. The figures indicate additional predicted scheduled cash earnings with various years of tenure when the level of regular cash earnings at zero years of tenure is standardized at 100.

Table A2-5. Summary of returns to human capital (male)

| | (1) Combined returns $\beta_1+\beta_2$ | (2) General $\beta_1$ | (3) Firm-specific $\beta_2$ |
|---|---|---|---|
| 2004-2009 (A) | 0.024 *** | 0.007 *** | 0.017 *** |
| | (0.003) | (0.002) | (0.003) |
| 2010-2015 (B) | 0.015 *** | 0.003 * | 0.012 *** |
| | (0.003) | (0.002) | (0.003) |
| Change (B-A) | -0.009 | -0.004 | -0.005 |

Note: This table corresponds to Table 5 in the main article. *** and * denote statistical significance at the 1 and 10 percent levels, respectively. Values in parentheses in column (1) indicate robust standard errors and column (2) and (3) are standard errors computed using the bootstrap (100 replications).

Table A2-6. Summary of returns to human capital (female)

| | (1) Combined returns $\beta_1+\beta_2$ | (2) General $\beta_1$ | (3) Firm-specific $\beta_2$ |
|---|---|---|---|
| 2004-2009 (A) | 0.025 *** | 0.005 | 0.019 ** |
| | (0.010) | (0.003) | (0.009) |
| 2010-2015 (B) | 0.014 *** | 0.007 ** | 0.008 |
| | (0.005) | (0.003) | (0.006) |
| Change (B-A) | -0.010 | 0.002 | -0.012 |

Note: This table corresponds to Table 5 in the main article. *** and ** denote statistical significance at the 1, 5 and 10 percent levels, respectively. Values in parentheses in column (1) indicate robust standard errors and column (2) and (3) are standard errors computed using the bootstrap (100 replications).

Table A2-7. Estimation result on effect of retirement age (male)

| Dependent variable: natural log of scheduled cash earnings | | | |
|---|---|---|---|
| | (1) | (2) | (3) |
| Period | 2005-2008 | 2009-2012 | 2013-2017 |
| Tenure | 0.052 *** | 0.105 *** | 0.070 *** |
| | (0.016) | (0.017) | (0.013) |
| Tenure$^2$ (×10$^2$) | 0.074 | -0.635 *** | -0.162 |
| | (0.177) | (0.186) | (0.142) |
| Tenure$^3$ (×10$^3$) | -0.069 | 0.213 *** | -0.007 |
| | (0.070) | (0.071) | (0.057) |
| Tenure$^4$ (×10$^4$) | 0.009 | -0.026 *** | 0.006 |
| | (0.009) | (0.009) | (0.008) |
| Interaction (Retirement age×tenure) | -0.0002 | -0.0011 *** | -0.0006 *** |
| | (0.0003) | (0.0003) | (0.0002) |
| Interaction2 (Retirement age×tenure$^2$) (×10$^2$) | -0.0018 | 0.0097 *** | 0.0022 |
| | (0.0029) | (0.0030) | (0.0022) |
| Interaction3 (Retirement age×tenure$^3$) (×10$^3$) | 0.0009 | -0.0037 *** | -0.0001 |
| | (0.0011) | (0.0011) | (0.0009) |
| Interaction4 (Retirement age×tenure$^4$) (×10$^4$) | -0.0001 | 0.0005 *** | -0.0001 |
| | (0.0001) | (0.0001) | (0.0001) |
| Retirement age | 0.0018 *** | 0.0025 *** | 0.0015 *** |
| | (0.0006) | (0.0007) | (0.0005) |
| College | 0.149 *** | 0.146 *** | 0.133 *** |
| | (0.002) | (0.002) | (0.002) |
| Constant | 7.867 *** | 7.894 *** | 8.085 *** |
| | (0.042) | (0.054) | (0.045) |
| Dummy variables | Yes | Yes | Yes |
| Observations | 394,229 | 373,105 | 497,125 |
| Adjusted R-squared | 0.811 | 0.811 | 0.801 |

Note: This table corresponds to Table 6 in the main article. *** denotes statistical significance at the 1 percent level. Values in parentheses indicate robust standard errors. In addition to the independent variables shown in the table, we include dummy variables on occupation, industry, firm size and prefecture.

Table A2-8. Tenure-wage profiles and impact of extending retirement ages (male)

| Accumulated returns to tenure at | (1) 2013 | (2) 2017 Without estimated effect of extending retiremet age | (3) 2017 |
|---|---|---|---|
| 1 year | 3.6 | 3.3 | 3.2 |
| 5 years | 17.2 | 16.0 | 15.4 |
| 10 years | 32.1 | 30.0 | 29.1 |
| 20 years | 53.6 | 50.2 | 49.2 |
| 30 years | 64.5 | 60.8 | 59.7 |

Note: This table corresponds to Table 7 in the main article. The figures indicate additional predicted scheduled cash earnings with various years of tenure when the level of regular cash earnings at zero years of tenure is standardized at 100.

Table A2-9. Estimation result on effect of retirement age (female)

| Dependent variable: natural log of scheduled cash earnings | | | | | | |
|---|---|---|---|---|---|---|
| | (1) | | (2) | | (3) | |
| Period | 2005-2008 | | 2009-2012 | | 2013-2017 | |
| Tenure | 0.046 | ** | 0.062 | *** | 0.074 | *** |
| | (0.021) | | (0.023) | | (0.016) | |
| $Tenure^2$ ($\times 10^2$) | 0.071 | | -0.098 | | -0.397 | ** |
| | (0.287) | | (0.299) | | (0.223) | |
| $Tenure^3$ ($\times 10^3$) | -0.131 | | -0.028 | | 0.097 | |
| | (0.130) | | (0.133) | | (0.103) | |
| $Tenure^4$ ($\times 10^4$) | 0.025 | | 0.006 | | -0.007 | |
| | (0.019) | | (0.019) | | (0.015) | |
| Interaction (Retirement age×tenure) | -0.0002 | | -0.0004 | | -0.0007 | *** |
| | (0.0003) | | (0.0004) | | (0.0003) | |
| Interaction2 (Retirement age×$tenure^2$) ($\times 10^2$) | -0.0030 | | -0.0004 | | 0.0042 | |
| | (0.0045) | | (0.0047) | | (0.0035) | |
| Interaction3 (Retirement age×$tenure^3$) ($\times 10^3$) | 0.0027 | | 0.0011 | | -0.0008 | |
| | (0.0020) | | (0.0021) | | (0.0016) | |
| Interaction4 (Retirement age×$tenure^4$) ($\times 10^4$) | -0.0005 | * | -0.0002 | | 0.0000 | |
| | (0.0003) | | (0.0003) | | (0.0002) | |
| Retirement age | 0.0001 | | 0.0009 | | 0.0012 | *** |
| | (0.0006) | | (0.0006) | | (0.0004) | |
| College | 0.170 | *** | 0.163 | *** | 0.142 | *** |
| | (0.004) | | (0.004) | | (0.003) | |
| Constant | 8.0388 | *** | 7.892 | *** | 8.135 | *** |
| | (0.052) | | (0.046) | | (0.042) | |
| Dummy variables | Yes | | Yes | | Yes | |
| Observations | 62,116 | | 64,944 | | 99,252 | |
| Adjusted R-squared | 0.751 | | 0.746 | | 0.730 | |

Note: This table corresponds to Table 6 in the main article. ***, ** and * denote statistical significance at the 1 percent, 5 percent and 10 percent levels, respectively. Values in parentheses indicate robust standard errors. In addition to the independent variables shown in the table, we include dummy variables on occupation, industry, firm size and prefecture.

Table A2-10. Tenure-wage profiles and impact of extending retirement age (female)

| Accumulated returns to tenure at | (1)<br>2013 | (2)<br>2017<br>Without estimated effect of extending retiremet age | (3)<br>2017 |
|---|---|---|---|
| 1 year | 3.0 | 3.0 | 2.9 |
| 5 years | 13.1 | 13.0 | 12.4 |
| 10 years | 23.1 | 22.3 | 21.5 |
| 20 years | 40.0 | 37.2 | 36.5 |
| 30 years | 54.7 | 49.8 | 49.0 |

Note: This table corresponds to Table 7 in the main article. The figures indicate additional predicted scheduled cash earnings with various years of tenure when the level of regular cash earnings at zero year of tenure is standardized at 100.