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**Schooling, employer learning,  
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Wage dynamics and human capital investment  
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**Abstract**

Employer learning model predicts the impact of schooling, an observable signal, on wages decreases with accumulation of experience. Workers, however, have incentives to invest in general human capital both at schools and workplaces such that experience and schooling are complements unless the current employer commits to long-term employment. Microanalysis of Japanese steel industry indeed shows that experience before employed by the firm is complementary to schooling and the complementarity effect dominates employer learning effect while wage growth after employed is consistent with learning hypothesis. It suggests that previous evidences of employer learning might contain internal labor market effect.

**Key words:** employer learning, schooling and wages, internal labor market effect.

**JEL:** J31, N35, J24.

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# 1 Introduction

## 1.1 Total experience or tenure?: Employers' learning and employees' incentives of human capital investment

While human capital or productivity of individual workers are hard to observe, educational background is one of the observable proxies supposed to be correlated to skill and future performance. It entices employers to statistically discriminate employees based on educational background, and the statistical discrimination could lead to considerable gap between wages and realized performance.<sup>1</sup> Wage could grow either because human capital is invested in after employed or because the employer learns employees' ability endowed before employed, and it is generally difficult to empirically distinguish them.<sup>2</sup> Inspired by the screening hypothesis, rich empirical results supporting "sheepskin effects" of schooling have been presented for the US and other several economies.<sup>3</sup> While there are evidences that schooling could enhance productivity, not only work just as a signal, and the quality of education, not only diploma, does matter,<sup>4</sup> it does not necessarily contradict with screening hypothesis. Schooling works as a strong signal as well as increases productivity. It is established that "sheepskin effects" themselves exist in all of developed, developing, and even planned economies. Then the issue in the literature has come to how the effects differ due to institutional arrangements, such as possible discrimination of gender, ethnic, or racial minority, ownership structure of firm, or regime of state.

Employer learning is one of the most exciting focal points of such a comparative analysis. The founders of screening models had interests both in education as a screening device itself and in social benefit of screening device to improve matching in the job market. Focusing on the former and considering rich empirical results to support it, the learning models established by Farber and Gibbons (1996) and Altonji and Pierret (2001) provide a clear prediction under

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<sup>1</sup>While the founders of "education as screening" hypothesis assumed education just as a screening device, it could be extended such that education also enhances productivity. Spence (1973), pp. 358-368. Arrow (1973), pp. 284-287. Tabman and Wales (1973), pp. 43-49. Stiglitz (1975), pp. 175-178. Spence (2002), pp. 436-443.

<sup>2</sup>Stigler (1962), pp. 100-101.

<sup>3</sup>For the US, Riley (1979), pp.240-s251, Lang and Kropp (1987), pp. 618-623, Hungerford and Solon (1987), pp. 175-177, Belman and Heywood (1991), pp. 721-723, Heywood (1994), pp. 228-232, Jaeger and Page (1996), pp. 734-738, Belman and Heywood (1997), pp. 628-635, Park (1999), pp. 238-240, Tyler, Murnane and Willett (2000), pp. 445-447, Bedard (2001), pp. 760-774, Pinkston (2003), pp. 651-656, Bollinger and Hirsch (2006), pp. 511-513, Trostel and Walker (2004), pp. 1965-1966, Clark and Jaeger (2006), pp. 772-788. Bitzan (2009), pp. 761-764. Hansen, Weisbrod and Scanlon (1970), pp. 411-416, also gives some evidences that became a part of screening hypothesis. For Japan, Bauer, Dross and Haisken-DeNew (2005), pp. 323-331. For the UK, MacGuinnes (2003), pp. 599-606, Silles (2008), pp. 218-219. For Canada, Ferrer and Riddell (2008), pp. 885-902, Ferrer and Riddell (2002), pp. 191-211, Caponi and Plesca (2009), pp. 1113-1124. For Spain, Pons and Blanco (2005), pp. 336-343, Pons (2006), pp. 144-151. For Czech, a transition economy, München, Svejnar and Terrell (2005a), pp. 104-119, and München, Svejnar and Terrell (2005b), pp. 280-293, which examine differences over regimes, firm ownerships, and gender during the transition period. Denny and Harmon (2001), p. 636, gives a quick comparison among the US, the UK, Canada, Ireland, and Sweden.

<sup>4</sup>Those evidences include Layard and Psacharopoulos (1974), pp. 989-992, Wolpin (1977), pp. 954-957. Groot and Oosterbeek (1994), pp. 319-321, Card and Krueger (1992), pp. 31-36, for the US, Chevalier, Harmon, Walker and Zhu (2004), pp. F505-516, for the UK, and Patrinos (1996), pp. 171-173, for Guatemala.

the competitive labor market that impact of schooling on wage decreases over workers' experience in the labor market as employers learn workers' types hidden at the time when they join the labor market. This learning effect is in estimation practice captured by non-increasing coefficient of the interaction of schooling and experience on a wage regression, and their empirical results support the prediction quite well, followed by supporting works about the US labor market.<sup>5</sup>

A simple, but not negligible feature common with Farber and Gibbons (1996) and Altonji and Pierret (2001) is in that they do not differentiate workers' experience before and after entering long-term employment, hence implicitly assume that learning go through "public"ly, or, symmetrically between incumbent employer and outside employers and that interaction between schooling and experience in principle do not change even after workers are successfully employed by a large firm that commits to long-term employment.

The employer learning hypothesis is straightforward from the viewpoint of employers who use educational background as a screening device and consistent empirical evidence has been presented as well. There still exists, however, some point yet to be inquired. Non-increasing coefficient of interaction term between schooling and experience implies not only that the employer is learning but also that schooling and experience are not complements, or their complementarity effect was sufficiently weak to be dominated by the employer's learning effect.<sup>6</sup> If non-increasing coefficient of interaction between schooling and experience observed, the result itself is a puzzle from the viewpoint of employees' incentives for human capital investment, observed under technology-skill complementarity.

In the German case, for instance, as Gathmann and Schoenberg (2010) clearly demonstrates, young workers typically invest in "portable" general human capital as switching jobs several times in their early stages of career, and then enter employment of long-term basis.<sup>7</sup> Also, productivity of labor and education of worker are thought to be closely correlated since the early 20th century, as industrial economies have experienced technology-skill/education complementary development.<sup>8</sup> In fact, educational background of workers has accordingly emerged as the important proxy of ability in workplaces exactly on this context of technology-skill/education complementarity.

Under the technology-skill/education complementary development, workers likely choose work experiences to invest in general human capital complementary to their educational background before he/she joins a firm that commits to long-term employment and internal promotion, i.e., internal labor market policy. Then schooling and experience might be complements. This effect would work to make interaction between schooling and work experience increasing over time.

On the other hand, if the current employee commits to long-term employment and internal promotion, then the employee has incentives of investment in the industry-specific and/or firm-specific human capital,<sup>9</sup> which might be less complementary to schooling, an opportunity of

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<sup>5</sup>Farber and Gibbons (1996), pp. 1010-1018. Altonji and Pierret (2001), pp. 316-323. Lange (2007), pp. 4-7. Oyer (2008), pp.278-287.

<sup>6</sup>Farber and Gibbons (1996), p. 1017.

<sup>7</sup>Gathmann and Schoenberg (2010), pp. 10-36.

<sup>8</sup>Fallon and Layard (1975), p. 295. Goldin and Katz (1998), pp.710-723.

<sup>9</sup>Based on the NLSY, Parent (2000), pp. 308-320, shows that industry-specificity has larger impact on wages

investment in general human capital. If complementarity between schooling and industry- and/or firm-specific skill is sufficiently weak to be dominated by employer learning effect, then the interaction between schooling and tenure in the firm is expected to be non-increasing over time.

While employer learning model is entitled as “public” learning model, its prediction in fact seems to better fit with employer learning process within internal labor market of large firms from the viewpoint of dynamics of workers investment in human capital, instead of the competitive outside market. The employer learning prediction has possibly captured wage growth distorted by internal labor market of large firms.

Indeed, succeeding close interest in the original employer learning model, Galindo-Rueda (2003), Schönberg (2007), Pinkston (2009) are conscious of a possible asymmetry in employer learning and thus particular effect of tenure in total experience, Bauer and Haisken-DeNew (2001) deals with human capital investment complementary to schooling, and Baker, Gibbs and Holmstrom (1994b) and Lluís (2005) deal with wage dynamics of internal labor markets. Knitting up these three attractive strands, this research tries to distinguish learning effects in wage growth in and out of internal labor market effect, using panel data of the Japanese steel industry exactly at the time when it introduced internal labor market policy.

## 1.2 Technology, skill, and organization

Desirable structure of organization depends on prevalence of relevant information, and technological conditions shape informational structure. Technological changes affect organizational structure in this way. It particularly holds for labor organization within a firm. Technological changes affect type of necessary skill, and it could determine which player, either employees or the firm, knows the skill better. If the firm knows better about necessary skill, then direct control of labor organization could provide employees with better incentives. Given technology, skill and information structure, a firm chooses a better organization to reduce loss from asymmetric information. In other words, through the firm’s decision, combination of technology, skill, and informational structure shapes labor organization. Internal labor market is a potential candidate when a firm knows necessary skills well and the skills are complementary to each other and/or firm-specific.<sup>10</sup>

Internal labor markets characterized by long-term employment and internal promotion are widely seen for high-skilled workers of large companies in developed economies. Labor organizations of white-collar employees and high-class engineers are not uniquely determined by

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than firm-specificity alone, which intuitively persuasive to us as a wage earner and seems to be applicable to other economies than the US. In addition, Weinberg (2001), pp.236-247, verifies that industry specificity does shield wages from exogenous shocks. Then, Poletaev and Robinson (2008), pp. 402-413, extracts impact of skill-specificity on wages, embedded in industry-specificity. At the same time, Shaw and Lazer (2008), pp. 717-720, extracts specific productivity gain of tenure at a specific firm, which implies the existence of firm-specific human capital and the relevancy of that at least to some extent. Therefore, more correctly, we had better state that internal labor market of a specific firm exists and it consists of industry-specificity and specific composition of skills. For simplicity, we tentatively skip the logical step here.

<sup>10</sup>Doeringer and Piore (1971), pp. 1-7. Williamson, Wachter and Harris (1975), pp. 269-277. Milgrom and Roberts (1992), pp. 358-385.

technology and are often firm-specific, so internal labor markets are widely applied on white-collar employees and engineers. It is also introduced for ordinary blue-collar employees of manufacturing in some industries where systematic procedures are required typically as in steel, petroleum refineries, paper mills, and so on.<sup>11</sup> These industries, at the same time, are the very ones which Goldin and Katz (1998) asserts have grown with technology-skill/education complementarity since the early 20th century.<sup>12</sup>

Empirical and descriptive works on the issue in the last two decades have rejected the traditional conjecture that, either in the US and in Japan, the internal labor market implies wage dynamics irrelevant to performance or merit. Rather, it is a evaluation device as a second best approach to make wages sensitive to performance of employees and to give employees incentives of investment in industry- and/or firm-specific human capital under asymmetric information. Thus it is expected the wages do not depart market price equal to marginal productivity in the long term on average, though they are not necessarily one-to-one equal in the short term.<sup>13</sup>

Japanese manufacturing, led by the steel industry as in the US, headed that way in the 1920s, and after the Second World War, developed even more internal-labor-market-oriented. Then “life time employment” came to be known as a feature of the Japanese manufacturing. As the US firms of good performance has continuously managed long-term employment,<sup>14</sup> it is not a unique culture of Japanese firm, while it is true that post-war Japanese firms have more steeply tilted to long-term employment and wage growth with tenure.<sup>15</sup> The point is arguably in that Japan experienced a faster and deeper transition of the same direction shared with other developed economies.

### 1.3 Transformation in the steel industry

Different from typically 20th century industries like petroleum refineries, transition to the internal labor market of major industries with longer tradition was accompanied by dissolution of autonomous intermediary labor organization into well organized labor organization directly and systematically planned by firms, as pointed out by the radical economists and then redefined as transition to a more efficient second best organization by new institutional economists.<sup>16</sup> Such a transition would proceed with technological transition that provides firms with informational advantages in acquisition of relevant human capital, which makes direct control by the firm relatively efficient.

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<sup>11</sup>Doeringer and Piore (1971), pp. 6, 50-51, 58.

<sup>12</sup>Goldin and Katz (1998), pp. 707-716.

<sup>13</sup>Alexander (1974), pp. 74-83, Aoki (1988), pp. 54-60. Baker, Gibbs and Holmstrom (1994a), pp. 881-884. Baker and Holmstrom (1995), pp. 256-257.

<sup>14</sup>Hall (1980), pp. 97-107. Hall (1982), pp. 719-720. A measure of the importance of long-term employment in human capital investment is relative impact of tenure at a firm and total work experience on wages. Abe (2000) shows based on the data of the 1980s that tenure alone had considerable impact on wages in the US while relative importance of tenure over experience is indeed larger in Japan than in the US (Abe (2000), pp. 261-264.).

<sup>15</sup>Hashimoto and Raisian (1985), pp. 721-732. Aoki (1988), pp. 59-69. Mincer and Higuchi (1988), pp. 112-115. Moriguchi (2003), pp. 640-652. While mobility of younger generations have increased since the 1990s, long-term employment is still prevailed practice among large Japanese firms. Ono (2010), pp. 13-22.

<sup>16</sup>Marglin (1974), pp. 60-81. Stone (1974), pp. 128-147. Williamson (1985), pp. 206-239.

As to the Japanese steel industry, big two phases of technological transition were seen in the 1920s and in the 1950s as larger open-hearth furnaces were introduced, and in the 1960s when converter furnaces were introduced under the American influence. Along with the technological transition, traditional skill ascriptive to individual senior employees was transformed to the skill manualized and known to the management.<sup>17</sup> As with in the American steel industry,<sup>18</sup> it was the core in the transition to frame a work organization with systematic wage and promotion scheme.

This paper deals with wage growth of blue-collar employees from 1929 to 1969 of the Kamaishi Iron Works,<sup>19</sup> a leading iron works then in Japan, and approaches to wage dynamics during formation of internal labor market. To be analyzed is micro data of 1490 employees of the Kamaishi Iron Works.

The section 2 presents the estimation model. The section 3 describes the data and then verifies existence of internal labor market at the case firm. The section 4 gives empirical results.

## 2 Estimation model under internal labor market effect

### 2.1 Employer learning

Consider a random effect model of panel least square regression of  $i$ th employee's wage ( $w$ ) at time  $t$ ,

$$(1) \quad w_{i,t} = \alpha_0 + \alpha_2 \text{yos}_i + \alpha_2 \text{yos}_i \times t + \alpha_3 t + \zeta_i + \epsilon_{i,t},$$

where  $\text{yos}_i$  stands for years of schooling that is observable to employer and stochastic  $\zeta_i$  captures time-invariant characteristics unobserved by the employer.

And put

$$(2) \quad \Delta_t w_{i,t} = \alpha_2 \text{yos}_i + \alpha_3 + \Delta_t E(\zeta_i | \text{yos}_i, t - 1) + \Delta_t \epsilon_{i,t} \equiv \alpha_2 \text{yos}_i + \alpha_3 + \varphi_{i,t},$$

where  $\varphi_{i,t}$  is shock in the  $t$ th year.

Then inference based on the public learning model by Farber and Gibbons (1996) and Altonji and Pierret (2001) brings a straightforward prediction as a benchmark.<sup>20</sup> Linear projection of  $w_{i,t}$  gives

$$(3) \quad \begin{aligned} E(w_{i,t} | \text{yos}_i) &= \hat{\alpha}_0 + \hat{\alpha}_1 \text{yos}_i + \hat{\alpha}_2 \text{yos}_i \times t + \hat{\alpha}_3 t \\ &= \hat{\alpha}_0 + \hat{\alpha}_1 \text{yos}_i + \frac{\text{Cov}(w_{i,t}, \text{yos}_i \times t)}{V(\text{yos}_i \times t)} \text{yos}_i \times t + \hat{\alpha}_3 t \\ &= \hat{\alpha}_0 + \hat{\alpha}_1 \text{yos}_i + \frac{\sum_{\tau=2}^t \text{Cov}(\varphi_{i,\tau}, \text{yos}_i \times \tau)}{V(\text{yos}_i \times t)} \text{yos}_i \times t + \hat{\alpha}_3 t. \end{aligned}$$

<sup>17</sup>In the case of department of maintenance, the Kamaishi Iron Works, intangible knowledge that had been inherited from senior workers to younger workers was made standardized, written as a rich manual and controlled by the firm in the early 1970s. Nakamura (2010), pp. 24-25.

<sup>18</sup>Novack and Perlman (1962), pp. 339-347. Stone (1974), pp. 128-136. Williamson (1985), pp. 234-236.

<sup>19</sup>belonged to Fuji Iron and Steel Corporation then, now belongs to Nippon Steel Corporation.

<sup>20</sup>Farber and Gibbons (1996), pp. 1010-1018. Altonji and Pierret (2001), pp. 316-323.

First, if schooling and experience are complements ( $\partial^2 y / (\partial y_{os} \partial \tau) > 0$ ), then  $\text{Cov}_i(\varphi_i, y_{os} \times \tau) > 0$ , and otherwise  $\text{Cov}_i(\varphi_i, y_{os} \times \tau) = 0$ , for each  $\tau$  ( $\tau = 2, \dots, t$ ). Second, if the employer learns employees' characteristics hidden when recruiting, which is captured by  $\zeta_i$ , then  $\text{Cov}_t(\varphi_t, y_{os} \times t) = 0$  for each  $i$ .

Suppose that wages, with marginal productivity, increase over experience and standardize variables by taking logarithmic terms.<sup>21</sup> Then, predicted are,

- (a) If the employer learns employees' hidden characteristics over time, and if schooling and experience are not complements or the effect of their complementarity is dominated by that of employer's learning, then  $\hat{\alpha}_2$  is expected to be negative.<sup>22</sup>
- (b) If schooling and experience are complements and the the effect of complementarity dominates that of the employer learning, then  $\hat{\alpha}_2$  is expected to be positive.

Based on the National Longitudinal Survey of Youth of the US, empirical evidences to support (a) have been presented.<sup>23</sup> It is also doomed that employer learning progresses fast especially in the first few years.<sup>24</sup>

## 2.2 Employees' incentives, asymmetric learning, and diversified labor markets

This prediction of employer learning does not explicitly consider workers' dynamic decision making of investment in human capital. Workers are reasonably expected to choose workplaces to maximize lifetime income, given their educational background. While both of the schooling market and the labor market have frictions, friction with choice of schools seems to be much larger.<sup>25</sup> It was the case especially prewar Japan where public elementary and secondary schools were dominant, and districts of elementary schools were determined by the government as they are now. Thus typically young people enrolled in assigned schools, graduated them, and finally made their own conscious decision when they chose workplaces.

Without particular constraints, people in the competitive open market, especially under employment contracts of short-term basis, are naturally to choose work experiences such that schooling and work experiences are complements if other conditions are the same.

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<sup>21</sup>While the standard wage regression of Mincer style regress logarithmic term of wage on raw level numbers, here in this research regressors are also transformed to logarithmic terms because estimation of the equation (4) with controlling all of cohort effects requires already many independent variables. The standard estimation model needs to contain squared terms of experience and tenure to allow their effects to be marginally decreasing, but adding squared terms here makes estimation results less readable. To allow experience and tenure effects to be marginally decreasing, here their logarithmic terms are used as regressors instead of squared terms of raw level.

<sup>22</sup>In the raw level term, non complementarity implies significantly zero of  $\hat{\alpha}_2$ . Standardization taking logarithmic term means, with increase of relative impact of time variant factors such as tenure, relative impact of interaction between schooling and tenure decreases over time if they are not complementary, which implies a negative sign.

<sup>23</sup>Farber and Gibbons (1996), pp. 1023-1029. Altonji and Pierret (2001), pp.329-342. Lange (2007), pp. 4-7.

<sup>24</sup>Gibbons, Katz, Lemieux and Parent (2005), pp. 698-714. Lange (2007), pp. 9-19. A similar case in Germany is presented by Lluís (2005), pp. 745-755.

<sup>25</sup>In addition, kids themselves tend to be ignorant about return of schooling as reported by Jensen (2010).



This direction of human capital investment has become even more desirable since the early 20th century, as technology-skill/education complementarity has become augmented with transition of production process from artisanal shops to factory system, continuous production system, and “computerized” production line<sup>26</sup>.

On the other hand, if the current employer commits to operating internal labor market policy consisting of long-term employment and internal promotion, then the employees could have incentives to invest in industry- and/or firm-specific human capital that might be less complementary to general skills that have been taught at schools. Indeed, in the case of the US, industry-specificity of human capital obviously decrease mobility of workers, and induce firms to protect wages and employment of experienced workers against exogenous shocks more than they do to young workers. That kind of commitment is necessary to entice workers invest in industry- and/or firm-specific human capital.<sup>27</sup>

The intensity of technology-skill/education complementarity and employers’ adjustment to it could affect institutional arrangement in the labor market and accordingly employer learning process. In the German case, after Bauer and Haisken-DeNew (2001) found the dominant effect of complementarity between schooling and experience and rejected employer learning effect,<sup>28</sup> Lluís (2005) succeeded in carefully mining some evidence of employer learning by controlling job-rank effects.<sup>29</sup> The German labor market appears to be modeled as friendly to investment in general human capital, compared with those in the US, the UK,<sup>30</sup> and Japan inquired by this research.

Another issue is the extent of asymmetry in employer learning. About the US labor market, Pinkston (2009) finds that informational structure in employer learning is asymmetrically favorable to incumbent employers and thus tenure has impact on learning additional to total experience,<sup>31</sup> while Schönberg (2007) evaluates that the asymmetry is not so large as it affects the speed of employer learning.<sup>32</sup> About the UK, on the other hand, as Galindo-Rueda (2003) recognizes strong evidence of employer learning, it also finds stronger learning effect of tenure, instead of total experience of workers, and asserts that incumbent employers have informational advantage in learning over entrant employers.<sup>33</sup> As later shown on **Table 3**, the same effect is clearly observed in the Japanese labor market.

Diversity of labor markets consists of institutional framework that encourages human capital investment and informational structure that enables employers to learn workers’ types. The coefficient of interaction term between schooling and experience is the tractable measure of employer learning. At the same time, this is a focal point of diversity of labor markets, which varies depending on institutions of human capital investment and informational structure about workers’ types.

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<sup>26</sup>Goldin and Katz (1996), pp. 253-256. Goldin and Katz (1998), pp. 698-719. Autor, Katz and Kearney (2006), pp. 190-191.

<sup>27</sup>Weinberg (2001), pp. 236-251.

<sup>28</sup>Bauer and Haisken-DeNew (2001), pp. 163-177.

<sup>29</sup>Lluís (2005), pp. 749-755.

<sup>30</sup>Galindo-Rueda (2003), pp. 8-17,

<sup>31</sup>Pinkston (2009), pp. 381-389.

<sup>32</sup>Schönberg (2007), pp. 672-678.

<sup>33</sup>Galindo-Rueda (2003), pp. 13-15.

### 2.3 Identification of the internal labor market effect in the wage growth

With concerns about investment in human capital, workers are expected to invest in general human capital both at schools and workplaces if their employers do not commit to internal labor market policy. On the other hand, employers do not generally have incentives to invest in general human capital of employees. If any, employers willingly invest in environments favorable to accumulation of firm-specific human capital. Then employees could have incentives of investment in firm-specific human capital if their employers do commit to internal labor market policy.

To capture this effect of internal labor market that potentially slips into strings of wage determination, empirical exercise later separates  $i$ th employee's experiences before and after he joined the firm that commits to internal labor market policy such as  $t = \text{epr} = \text{pvr} + \text{ten}$ , where  $\text{pvr}$  is experience before he joined the case firm,  $\text{ten}$  is tenure at the firm, and  $\text{epr}$  is total experience. Then the wage regression equation (3) is reformulated as

$$(4) \quad \begin{aligned} w_{i,t} = & \beta_0 + \beta_1 \text{yos}_i \\ & + \beta_2 \text{yos}_i \times \text{pvr} + \beta_3 \text{yos}_i \times \text{ten} \\ & + \beta_4 \text{epr} + \beta_5 \text{ten} + \boldsymbol{\gamma}^T \mathbf{x}_i + \boldsymbol{\delta}^T \mathbf{x}_i \times \text{ten} + \zeta_i + \epsilon_{i,t}, \end{aligned}$$

where  $\mathbf{x}_i$  stands for time-invariant characteristics vector other than educational background.<sup>34</sup>

Taking logarithmic terms of variables, predictions from employer learning combined with workers' concerns about investment in human capital are,

**Prediction 1.** *the interaction term between years of schooling and previous experience before employed by the firm ( $\text{yos} \times \text{pvr}$ ) is expected to have positive coefficient ( $\hat{\beta}_2 > 0$ ), which indicates that complementarity between schooling and work experiences is strong enough to dominate the employer's learning effect,*

and,

**Prediction 2.** *the interaction term between years of schooling and tenure after employed by the firm ( $\text{yos} \times \text{ten}$ ) is expected to have negative coefficient ( $\hat{\beta}_3 < 0$ ), which indicates that the firm learns employees' hidden characteristics over tenure, and that schooling and tenure are not complements, or the learning effect dominates their complementarity effect if any.*

It is examined in the section 4.3 whether this prediction is supported or not.

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<sup>34</sup>Bauer and Haisken-DeNew (2001), pp. 163-170, applies this formulation of regression on the German data to inquire whether employers' go "public"ly in the labor market (through workers' total experience) or "private"ly (thorough tenure at specific firms), and denies any employer learning effect, which is strikingly different result from the US and Japan cases. We will be back to this point in the section 5.1. Also, Schönberg (2007) adds tenure to experience as regressors in the wage regression, to inquire possible difference in learning processes of incumbent and outside employers.<sup>35</sup>

## 3 The case firm and the data

### 3.1 Kamaishi Iron Works on its historical context

Kamaishi Iron Works is the oldest iron works in Japan, opened by the Nambu Domain in 1857. After nationalized in 1873 and privatized again in 1884, new blast furnaces were built and began continuous production from iron to steel in 1903. After owned by the Mitsui holdings, the largest conglomerate, in 1924, it was merged with other major iron works into Nippon Iron and Steel in 1933. The merge was coordinated by the government for technological improvement. Traditional skill required for the early 20th century technology had developed in its labor organization as it started modernization efforts in the 1930s.

Then, Japan entered the war against the US, and during the wartime isolation, Japanese steel industry turned out to be backward. After the Second World War, steel companies as well as other important manufacturing companies were induced to invest in new technology with long-term financing coordinated by the government. For the iron and steel industry, three coordinated modernization investments were planned. The “1st plan” was 1951-1954, the “2nd plan” was 1956-1960, and the “3rd plan” was 1961-1964. Through the plan, for the Kamaishi Iron Works, then an iron works of Fuji Iron and Steel, now Nippon Steel, improvement of efficiency in iron and steel production and expansion of fine steel production were emphasized, but replacement of old blast furnaces was not planned.

A big change during the modernization since the 1950s at production lines was standardization, or “manualization,” of production procedures. Before the Second World War, in the iron and steel industry, sophisticated procedures of production were developed by employees and taught to younger employees by the elder. Since the 1950s, however, procedures of production lines became manualized by better educated engineers, and the best practices at the shop floor came to be known to the firm.<sup>36</sup>

As a part of company wide investment plan, Fuji Iron and Steel decided to build a new state-of-the-art plant called Tokai in Nagoya, now an iron works of Nippon Steel. Because it was a new plant, skilled workers were not there. About iron production capacity, the firm decided to decrease Kamaishi’s and to increase other new plants such as Tokai, and to relocate skilled workers of Kamaishi and other old iron works to Tokai. Then 1,678 skilled workers moved from Kamaishi to Tokai in 1964, 1967, 1968, and 1969.<sup>37</sup>

### 3.2 The data

This research uses preserved 1,490 of relocated Kamaishi employees’ panel data of wages, tracking from the late 1920s or later, depending on employee, to the 1960s, when they left Kamaishi. This data set has both considerable disadvantage and advantage.

The disadvantage is about selection and survival biases. Selection for relocation was handled under close dialogue and coordination between the firm and the union, and, in principle,

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<sup>36</sup>Nakamura (2010), pp. 8-21.

<sup>37</sup>With 1,678 from Kamaishi, 908 from Muroran, 972 from Hirohata, and 127 from Kawasaki were relocated. Umezaki (2010), pp. 33-38.

anyone who was willing to move were accepted. Thus, there was not a clear and intended measure to select employees for relocation.<sup>38</sup> However, it is not followed that this is an unbiased sample set. First, employees who willingly moved to Nagoya were those who believed that they would get successfully used to the most advanced plant. They were more ambitious and/or self-confident employees than average. Second, all of the sample employees were those who had worked until they moved to Nagoya in the 1960s. The “losers” in the internal competition at Kamaishi who dropped are not included. Selected employees were likely to be the employees trained to get used to new technology, and well built-in internal labor market that was formed during the technological transition.

At the same time, the data set also has advantages respectable especially for this research. Intrinsically to original personnel documents, the documents contain all important information on employees’ CV when they were employed. It enables us to recover their whole life from the time when they were born to the late 1960s when they were relocated. The information includes records of previous working experiences not only educational record, and physical features such as height, weight, and lung capacity, which were thought to be important for blue-collar workers.

Each individual wage record includes:

1. Educational background (yos).
2. Physical characteristics when employed: height (hgt), weight and lung capacity.
3. Panel data of
  - (1) record of in-house training if the employee completed one:
    - Systematic programs for those selected from newly employed employees:
      - 1927-1935: “Youth Development Center (*Seinen Kunrenjo*)” (ydc). Three days a week, 4 years, 300 hours as total.
      - 1935-1948: “School for Youth (*Seinen Gakko*)” (sy). Halftime, three days a week.
      - 1939-1946: “Development Center for Technicians (*Ginsha Yoseijo*)” (dct). Fulltime, 3 years, 6,453 hours as total.
      - 1946-1973: “Development Center (*Kyoshujo*)” (dc). Three days a week, 2 years (by 1950), 6 days a week (from 1950). From 1953, only high school graduates were admitted.
    - Short term programs (ex. elementary calculus).
  - (2) licenses the employee held.
  - (3) family composition.
  - (4) clinical history.
  - (5) basic wages.

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<sup>38</sup>Umezaki (2010), pp.47-49.

- (6) promotion and deployment: classes, division and department assignment, and job assignment. The 49 divisions, 174 departments and 110 jobs have been recorded in the total.

The panel data of the basic wage starts when the employee joined the firm, and ends at the time when he moved to the Tokai Iron Works, varying from 1964 to 1969.

Composition of cohorts is shown on **Table 1**. A small peak is across from 1938 to 1942, when the wartime effort hit the peak with invasion to China in earnest from 1937 and the attack to the Pearl Harbor in 1941, followed by the American backfire including carpet bombing on the city of Kamaishi, and a bigger peak is across from 1948 to 1951, when the Japanese economy began to recover from the wartime destruction.

An especially important feature of the data set is in that those who were employed immediately after graduation are not dominant, which might not look typical in Japanese firm. The recruitment practice to employ new graduates was being prevailed for blue-collar workers since the mid 1960s, and not typical at all before that time. Indeed, the mean of previous experience (years after graduating school and before being employed by the firm, *pvr*) is even not monotonically decreasing.

Since the late 19th century, when the heavy manufacturing was introduced from the Western world, career path of experiencing several workplaces to acquire skill and then to be employed by a large firm in the long-term basis, or to start own workshop became a typical one among skilled workers. This tradition is not only well exploited by this research strategy on the equation (4). So-called “port of entry” practice of typical “Japanese firm,” under which employees are employed immediately after they graduate schools without experience at any other workplace was not prevailed for blue-collar workers even at the leading firm of the steel industry, the core industry then, in the covered period. It could allow empirical results of this research to be comparable to other industrial economies.

Compulsory education was extended from 6 years to 9 years in 1947, as shown in the minimum years of schooling on **Table 1**. Difference of educational background across employees who graduated before 1947 is distributed mainly between 6 years of completing mandatory elementary school and 8 years composed of mandatory 6 years and 2 years of completing high elementary school. **Table 1** shows graduates of high elementary school were majority before 1947.<sup>39</sup> Difference of employees who graduated after 1947 is distributed mainly between the mandatory 9 years of elementary school (6 years) and junior high school (3 years) and the 12 years of mandatory 9 years plus additional 3 years of high school. High school graduates were minority still in the 1960s.

### 3.3 Verifying existence of internal labor market

Before estimating the equation (4), the existence of internal labor market policy, which somehow “shields” wage determination from the outside market, itself to be empirically established. We basically follow the strategy presented by Baker et al. (1994b).

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<sup>39</sup>Already in the 1920s, major factories of heavy industry had preference of graduates of high elementary schools to those of elementary schools, especially for candidates of foremen. Sugayama (2011), p. 37.

If a firm offers competitive wages to revealed characteristics such as educational background of prospective employees in the market when the firm recruits workers, and if the firm adopts internal labor market policy under which wages are determined based on internal rules or evaluation that not more or less “shield”s internal wage dynamics from the market price, then wage growth of each cohort could share common trend “shiled”ed from the market price. Thus survival of cohort effect is a useful indicator of existence of internal labor market that somehow “shields” wage determination from the outside price mechanism at each point,<sup>40</sup> though it does not imply wage that the dynamics deviates the market price in the long term.

**Table 2** contains regression of real daily wages (*rw*) on experience in the labor market (*epr*), tenure (*ten*), years joined dummy (*yj*), and interaction between years joined dummy and tenure (*yj* × *ten*). To control composition effect of educational background varying over cohorts, years of schooling (*yos*) is also inserted as a regressor. The period saw a rapid growth of average productivity, which is controlled by year dummies. On the model 1-2, to allow marginally decreasing of cohort effect, interaction term of years joined dummy and tenure (*yj* × *ten*) is inserted as a regressor instead of tenure (*ten*).<sup>41</sup>

Cohort effects generally survive among employees of all cohorts. The internal labor market at the Kamaishi Iron Works seems to have been formed in the 1930s. This statistical inference is consistent with descriptive picture based on documents and hearings.<sup>42</sup>

Thus the basic wage at the first year shows the open market price of his labor, and the growth of the basic wage in the following year shows the firm’s evaluation of his labor based on some internal measures.

In addition, wage *rw* shows obvious serial correlation. Auto regression with random effects of real wage (*rw<sub>ten</sub>*), with years of education (*yos<sub>i</sub>*) and year dummies inserted, gives,<sup>43</sup>

$$(5) \quad \log rw_{ten} = \frac{0.3424}{21.6217^{**}} - \frac{0.0080}{16.1141^{**}} yos + \frac{0.8426}{354.7567^{**}} \log rw_{ten-1},$$

where absolute value of the coefficient of lagged term (*rw<sub>ten-1</sub>*) is smaller than 1, which means each history of wage is a contraction mapping.<sup>44</sup> Thus each wage history is heading for somewhere stationary.

Furthermore, a regression of real wage on more lagged terms gives with random effects

<sup>40</sup>Baker et al. (1994b), pp. 923, 933-940. Baker and Holmstrom (1995), pp. 258-259.

<sup>41</sup>Our approach differs from Baker et al. (1994b) in some important points. In order to avoid identification difficulty but to extract cohort effect, Baker et al. (1994b) assumes that tenure effect on wage growth is linear and estimates the coefficient of linear regression of wages on tenure, deducts the estimated tenure effect from cohort average wage, and regress this adjusted cohort average wage on cohort dummies. However, tenure effect is not necessarily linear in general. Also, two-staged estimation seems to have cohort effect appear larger than real. Hence, to deal with identification problem, we simply bind adjacent two cohorts together into one group, and then regress wages on two-cohort groups.

<sup>42</sup>Umezaki (2010), pp. 42-51.

<sup>43</sup>Estimation: Panel estimated generalized least squares with cross-section random effects. Year dummies: Yes. Sample periods: 40 (1930-1969). Cross-sections included: 1,482. Total panel observations: 20,511. The *t* statistics are within parentheses, where \*\* stands for significance smaller than 1 percent. Adjusted *R*<sup>2</sup>: 0.9691. *F*-statistic: 15,706.8328\*\*.

<sup>44</sup>It implies that extended growth curve of wage has unique fixed point.

and year dummies gives,<sup>45</sup>

$$\begin{aligned}
(6) \quad \log rw_{\text{ten}} = & \frac{0.3338}{(21.2829^{**})} - \frac{0.0004}{0.7289^{**}} \text{yos} \\
& + \frac{0.4450}{(52.8953^{**})} \log rw_{\text{ten}-1} + \frac{0.1485}{(17.6055^{**})} \log rw_{\text{ten}-2} \\
& + \frac{0.0765}{(9.0439^{**})} \log rw_{\text{ten}-3} + \frac{0.0592}{(7.4901^{**})} \log rw_{\text{ten}-4} \\
& + \frac{0.0640}{(8.4776^{**})} \log rw_{\text{ten}-5} + \frac{0.0394}{(5.5702^{**})} \log rw_{\text{ten}-6} \\
& + \frac{0.0332}{(5.1365^{**})} \log rw_{\text{ten}-7} + \frac{0.0226}{(4.8108^{**})} \log rw_{\text{ten}-8}.
\end{aligned}$$

While the past has significant impact on the current wage growth, the impact is monotonically decreasing, with each wage history going to some stable phase.<sup>46</sup>

Periods in concern saw rapid growth of labor productivity in the industry, hence average wage accordingly rapidly grew on average. On the equations (5) and (6), however, the effect is controlled by the year dummies inserted.

Therefore, followed from serial correlations seen on the equations (5) and (6), first, the sample employees are heterogeneous and there were “systematic winners and losers”<sup>47</sup> probably due to different ability of human capital accumulation,<sup>48</sup> and second, wage dynamics is on trajectory to some steady state, which is supposed to be true value of the employee’s “latent” ability. Though this process with serial correlation is not directly drawn from the “pure” employer learning model, it is consistent with secondary story derived from the employer learning model. If the employer, for instance, uses accumulated information for assignment of employees, then such a regularly serial correlation could be observed<sup>49</sup>

Thus the monotonic shape of trajectory is at least partly due to the employer’s learning process.

## 4 Empirical results

### 4.1 Overview: Tenure, employer’s learning, and in-house training

Before directly going to estimation of the equation (4), let us give an overview based on the ordinary regression equation (3). **Table 3** gives results of random effect estimation regressing real wage (rw) on height when employed by the firm (hgt), years of schooling the employee

<sup>45</sup>Estimation: Panel estimated generalized least squares with cross-section random effects. Year dummies: Yes. Sample periods: 33 (1937-1969). Cross-section included: 1,093. Total panel observations 11,393. Adjusted  $R^2$ : 0.9623.  $F$  statistic: 7099.4704\*\*.

<sup>46</sup>Absolute values of all real roots of  $1 - 0.4450z - 0.1485z^2 - 0.0765z^3 - 0.0592z^4 - 0.0640z^5 - 0.0394z^6 - 0.0332z^7 - 0.0226z^8 = 0$ ,  $z = -1.8900, 1.0476$ , are greater than 1, which implies the auto-regression equation (6) is stationary as the equation (5) is.

<sup>47</sup>Baker and Holmstrom (1995), p. 257. The result is theoretically predicted by symmetric learning of the employer and the employee (Gibbons and Waldman (1999), pp. 1333-1341.).

<sup>48</sup>Baker et al. (1994b), p. 947.

<sup>49</sup>Baker et al. (1994b), pp. 924, 926-927.

had completed (*yos*), experience in the labor market (*epr*), tenure at the firm (*ten*), interaction of height and experience ( $\text{hgt} \times \text{epr}$ ), interaction of height and tenure ( $\text{hgt} \times \text{ten}$ ), interaction of years of schooling and experience ( $\text{yos} \times \text{epr}$ ), interaction of years of schooling and tenure ( $\text{yos} \times \text{ten}$ ), dummy variables of completing in-house training programs, Development Center for Youth (*dcy*, operated in 1927-1935), School of Youth (*sy*, operated in 1935-1948), Development Center for Technicians (*dct*, operated in 1939-1946), Development Center (*dc*, operated in 1946-1973), interaction of them and tenure ( $\text{dcy} \times \text{ten}$ ,  $\text{sy} \times \text{ten}$ ,  $\text{dct} \times \text{ten}$ ,  $\text{dc} \times \text{ten}$ ).<sup>50</sup> The compulsory schooling was extended from 6 years of elementary school to 9 years of 6-year elementary school and 3-year junior high school in 1947. Since extension of compulsory schooling could have big impact of wages,<sup>51</sup> the postwar education generation dummy (*psw*) is inserted.

Tenure is robustly significant in all regressions. Experience within the firm strongly contributed to wage growth. At the same time, the employer learning hypothesis strongly holds when the data set handled as a whole. On **Table 3**, interaction terms of years of schooling both with experience after graduation ( $\text{yos} \times \text{epr}$ ) and tenure ( $\text{yos} \times \text{ten}$ ) are significantly negative in the models of 3-2 and 3-4. Negatively significant coefficient of  $\text{yos} \times \text{ten}$  indicates that the current employer learned better than previous employers, as the British case.<sup>52</sup>

As well as years of schooling, a proxy of ability observable to the employer when employed is physical characteristics such as height. Height is thought to sometime affect wages sometime,<sup>53</sup> while the channel is still ambiguous especially for white-collar workers.<sup>54</sup> In the case of blue-collar workers in the steel industry, the industry of masculine then, however, the physical strength was definitely critical especially in the department of pig iron production where workers required to be tough against extremely high-temperature and to still make difficult decision about how to manage blast-furnace that determined the quality of pig iron, the raw material of high-value-added of fine steel. Thus height is a good proxy of physical strength. Again, also about height, the employer's learning hypothesis holds. Interaction terms of height with tenure ( $\text{hgt} \times \text{ten}$ ) has significantly negative coefficient in the models 3-3 and 3-4.

## 4.2 Schooling and in-house training programs

**Table 3** also shows that role of training programs changed over time. The interaction of postwar program with tenure ( $\text{dc} \times \text{ten}$ ) has significantly negative coefficient while the interaction terms of prewar programs with tenure ( $\text{dcy} \times \text{ten}$ ,  $\text{sy} \times \text{ten}$ ,  $\text{dct} \times \text{ten}$ ) have significantly positive ones in the models 3-1, 3-2, 3-3, and 3-4.

All of Development Center for Youth, School of Youth, Development Center for Technicians, and Development Center were operated exclusively for newly employed employees at entry-level. As some of entry-level employees were chosen, the employer had not yet learned

<sup>50</sup>Some samples lack the information of height, weight, and lung capacity.

<sup>51</sup>Oleopoulos (2005), pp. 158-170.

<sup>52</sup>Galindo-Rueda (2003), pp. 13-15.

<sup>53</sup>Hersch (2008), pp. 369-375.

<sup>54</sup>Kuhn and Weinberger (2005), pp. 418-420.



hidden types of employees and the firm likely used some proxy to choose trainees from newly employed employees. In particular, the change in sign of interaction terms from prewar the programs (dcy, sy, dct) to the postwar program (dc) can be attributed to selection policy of Development Center (dc), which admitted only high school graduates since 1953. Closely linked to educational background, the effect of in-house training program also came to decrease over time as the employer learned types of employees hidden when employed.

### 4.3 Internal labor market effect

The empirical overview so far has established that employer learning hypothesis saliently holds particularly after employed as interactions of years of schooling and height with tenure ( $yos \times ten$ ,  $hgt \times ten$ ) have significantly negative coefficients. Next we proceed to extraction of some information about interaction between employees' history before employed by the firm and wages.

Now examine the equation (4) and the drawn **Prediction 1.** and **Prediction 2.** in the section 2.3. **Table 4** presents a regression of real wage (rw) on years of schooling (yos), experience after graduation and before employed by the firm (pvr), tenure after employed by the firm (ten), interaction of cohort dummy, years of schooling and previous experience before employed by the firm ( $yj \times yos \times pvr$ ), interaction terms of cohort dummy, years of schooling and tenure ( $yj \times yos \times ten$ ), with controlling training programs (dcy, sy, dct, dc), interaction terms between training programs and tenure (dcy  $\times$  ten, sy  $\times$  ten, dct  $\times$  ten, dc  $\times$  ten), and interactions between year dummy and years of schooling (dy  $\times$  yos) to capture changes in return of schooling over the period.

Then, except for early cohorts up to the mid 1930s, interaction term between years of schooling and tenure ( $yos \times ten$ ) has significantly negative coefficients also here, which supports the employer learning hypothesis by Farber and Gibbons (1996) and Altonji and Pierret (2001) as well as the **Prediction 2.** in the section 2.3. However, interaction of years of schooling and previous experience ( $yos \times pvr$ ) has significantly positive coefficient, which violates the employer learning hypothesis and supports the **Predictions 1.** of workers behavior in human capital investment in the section 2.3.

An immediate interpretation of the result on **Table 4**, considering average years of previous experience on **Table 1**, is that workers had chosen workplace experiences given their educational background such that they were in fact complementary to schooling before employed by the firm in the first several years in their job career, and, after employed by the firm, invested in firm-specific human capital not necessarily complementary to schooling, as the firm also learned employees' ability that was not indicated by educational background. Workers invested in general human capital at schools and workplaces before they joined the internal labor market, and turned to investment in human capital less complementary to schooling after they joined. This is a story consistent with the result.

While regression of wages on the interaction term between years of schooling and experience ( $yos \times epr$ ) on **Table 3** suggests that employer learning holds, the results on **Table 4** indicates that coefficient of the interaction term between years of schooling and experience ( $yos \times epr$ ) could be divided into two effects of before and after employed by the firm

( $yos \times pvr$ ,  $yos \times ten$ ), whose coefficients' signs are opposite.

Employer learning is assumed to be “public” learning in the competitive labor market (Farber and Gibbons (1996)). However, the result here, along with Galindo-Rueda (2003) and Pinkston (2009), shows that learning effect does not dominate complementary effect of schooling and experience as workers invested in general capital in their early stages of career. Employers' learning is observed rather after workers joined the internal labor market and were separated from the competitive market, instead of “public”ly going through the competitive market. Interaction term between years of schooling and experience ( $yos \times epr$ ) on **Table 3** appears to support employers' learning, but it is not because the workers ability came to be “public”ly learned in the market over time, but because results are affected by employer's learning and corresponding promotion of employees after incorporated to the internal labor market.

Indeed, coefficient of the interaction term between years of schooling and previous experience ( $yos \times pvr$ ) is significantly positive, as that between years of schooling and experience after employed by the firm ( $yos \times ten$ ) is significantly negative on **Table 4**. Because the latter effect is dominant, it appears, coefficient of interaction between years of schooling and experience ( $yos \times epr$ ) on **Table 3** is negative. In this sense, significantly negative coefficient of the interaction term between years of schooling and and experience ( $yos \times epr$ ) seems to capture an effect of the internal labor market.

## 5 Discussion: implication of the empirical result

### 5.1 Identification of internal labor market effect and comparative analysis of labor markets

As employers' learning hypothesis assumes learning is publicly going in the labor market, previous empirical studies such as those based on NLSY have not differentiated employers' learning outside and within the firm (Farber and Gibbons (1996), Altonji and Pierret (2001)). On the other hand, the representative works of modern approach to the internal labor market does not provide clear answer to the mixed picture, which partly supports employers' learning, on-the-job training, or comparative advantage hypotheses (Baker et al. (1994b), Gibbons et al. (2005), Lluís (2005)).

Some empirical evidences indicate that long-term employment is seen and does have positive impact wages and job protection on in the American workplaces, to encourage industry-, firm-, and/or skill-specific human capital.<sup>55</sup> In addition, since the 1930s, basic wages of American workers in fact have been even more shielded to exogenous demand shocks than Japanese and British counterparts due to institutional settings of the labor market,<sup>56</sup> and some empirical results support the existence of implicit contract to shield wages from macroeconomic shocks

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<sup>55</sup>Hall (1980, 1982). Abe (2000), pp. 258-263. Weinberg (2001), pp. 236-251. Poletaev and Robinson (2008), pp. 400-413.

<sup>56</sup>American firms seem to adjust workdays instead of basic wages to demand shocks. Gordon (1982), pp. 18-42.

in the US.<sup>57</sup>

Furthermore, exactly based on NLSY, Parent (1999) shows, first, current employers reward on-the-job training completed with themselves, second, current employers also reward on-the-job training their employees completed with previous employers, and third, employees who completed on-the-job training with current employers have lower separation rate.<sup>58</sup> The result mentions that young American workers join long-term basis employment after they accumulate experiences to be appreciated by the last employer.

Moreover, conjecture of employer learning in early stages has succeeded in provision of concrete result empirical studies in an intra-firm data set<sup>59</sup> while a study based on NLSY, which include mixed ingredients of employees who are already incorporated into long-term employment and yet to be gives much less clear result.<sup>60</sup> Also here in intra-firm data of Japanese steel industry, the faster employer learning the earlier stage principle is presented very clearly on **Table 4**, as later cohorts, which capture employer learning effects on early stages, show larger absolute value of negative coefficients of interaction term between years of schooling and tenure ( $yos \times ten$ ).

Along with the evidences, this case study suggests probability that existent empirical results to support the employers' learning has been affected either by the effect of incumbent employers' asymmetric learning or by investment in industry- and/or firm-specific human capital, instead of symmetric learning in the competitive labor market.

The extent of asymmetry of employer learning, and the extent of complementarity between schooling and experience could vary over economies, of course. As Galindo-Rueda (2003), Schönberg (2007) and Pinkston:2009 mention that employer learning goes a little more symmetrically in the US than in the UK.<sup>61</sup> Also, investment in human capital in Germany inquired by Bauer and Haisken-DeNew (2001) seems to concentrate in industry-specificity instead of firm-specificity even more than in the US labor market studied by Weinberg (2001).<sup>62</sup> If skill is perfectly standardized within each industry different from the US, and if secondary schooling emphasizes vocational education for specific industries more, instead of liberal arts, then skill is almost always general to the most workers who do not change industry in their life courses and schooling and work experience are intrinsically complements.

Compared with the presented evidences for the US, the UK, and Germany, the result of this research mentions that the Japanese labor market in the early half of the 20th century was closer to the contemporary British than to the contemporary American, in terms of symmetry of informational structure for employer's learning, and closer to the contemporary American than to the contemporary German, in terms of comparative emphasis on industry- or firm-specificity of human capital investment.

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<sup>57</sup>Beaudry and DiNardo (1991), pp. 675-685. Similar results for Canada are presented by McDonald and Worswick (1999), pp. 886-888. The same institutional setting of "shielding" could make wages sensitive to the employer's prosperity instead of the market and thus serial correlational, as shown by Dohmen (2004), pp. 746-752.

<sup>58</sup>Parent (1999), pp. 305-315.

<sup>59</sup>Lluis (2005), pp. 745-755.

<sup>60</sup>Gibbons et al. (2005), pp. 698-714.

<sup>61</sup>Galindo-Rueda (2003), pp. 13-15. Schönberg (2007), pp. 672-675, Pinkston (2009), pp. 381-389.

<sup>62</sup>Weinberg (2001), pp.236-247. Bauer and Haisken-DeNew (2001), pp.166-177.

To proceed such a comparative analysis, further inquiry based on panel data of employees who work for specific firms is desired. In this sense, the literature following Lluís (2005) that focused on employer learning and matching within internal labor markets are hoped to be enriched, and this case study hopefully is one of them.

## 5.2 Learning in early stages

**Table 4** also shows that coefficient of interaction between years of schooling and tenure and  $years \times tenure$  decreases as cohort goes down. It indicates that employer's learning went faster in the late periods. Since later cohorts have shorter tenure, employer's learning effect observed with later cohorts show employer's learning in the first few years. Lluís (2005) infers that learning effect had larger impact in earlier tenure in internal labor markets, based on the German data.<sup>63</sup> The result here is consistent with the inference.

## 5.3 Schooling, internal labor market, and dual structure

After the Second World War, the Japanese government extended mandatory schooling from 6 years to 9 years, and the number of high schools drastically increased. The explosive expansion of secondary schooling, which proceeded in the 1920s in the US, occurred in Japan from the 1950s to the 1960s. Secondary school system in prewar Japan, introduced from Europe, was the one to train a small group of elites. It was completely transformed into massive investment in human capital of majority people, which was a case of convergence to the American system of secondary education, along with convergence to the US-led technology-skill complementary development.<sup>64</sup>

Postwar junior high schools and most of high schools have focused on general education, not vocational education concentrating on particular and inflexible skills. The “uniquely-American invention”<sup>65</sup> of extended secondary school in the early 20th century was introduced to Japan after the Second World War, accompanied with rapid increase of capital-labor ratio, in the economic race to catch up with the US.<sup>66</sup> It directly led to supply of higher educated blue-collar labor force to the manufacturing sector. In despite of the rapid increase of better educated workers, the significantly positive coefficient of postwar education dummy ( $psw$ ) on **Table 3** shows that return of schooling rather increased after the Second World War.<sup>67</sup>

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<sup>63</sup>Lluís (2005), pp. 745-755.

<sup>64</sup>Goldin (2001), pp. 269-275. Ueshima, Funaba and Inoki (2006), pp. 72-73.

<sup>65</sup>Goldin (1998), p. 350.

<sup>66</sup>Godo and Hayami (2002), pp. 968-974.

<sup>67</sup>This is mainly because coverage of this research is up to the 1960s. An empirical study on the manufacturing sector as a whole indicates that wage premium with graduation of high school or more hit the highest in the mid 1960s, and had gradually declined since then (Ohkusa and Ohta (1994), p. 180-181). Ueshima (2003) argues that the educational wage differential was squeezed by rapidly increased supply of high-school graduates (Ueshima (2003), pp. 47-48.), as it was in the US in the mid 20th century, though institutional factors had a significant role in the US (Goldin and Margo (1992), pp. 17-32. Goldin (1999), pp. s80-s92.). As the most of a cohort came to enrol high school by the end of the 1970s, and the educational wage differential became an issue between college graduates and high school graduates. In the 1980s, while wage differential between college and high school graduates rose astonishingly in the US, the rise in Japan was relatively modest (Katz and Revenga (1989),

It indicates that, responding to increased supply of higher-educated workforce, technology-skill/education complementarity was augmented along with manualization of production line, and the transition rather increased demand for more educated workers and pulled up return on education,<sup>68</sup> as happened in the US from the 1920s to the 1940s.<sup>69</sup> Also, massive investment in public education by the government apparently succeeded in release of the society from the “low skill trap” equilibrium.<sup>70</sup> As result, productivity of the Japanese manufacturing sector is estimated to overtake the British in the 1970s, and the German in the 1980s, closing the gap with the American though still behind.<sup>71</sup>

The Kamaishi Iron Works took the trend and invested more in higher educated workers after the Second World War, as the negative coefficient of interaction between years of schooling and Development Center dummy ( $yos \times dc$ ) on **Table 3** mentions.

While “port of entry,” where only young workers are employed and are assigned to the lowest ladder, is a symbolic feature of internal labor market suggested by Doeringer and Piore (1971), it is not always empirically supported.<sup>72</sup> In the case of Japanese manufacturing, it became a dominant practice in the 1960s, much later than formation of internal labor market in the 1930s. It had become a common practice of personnel management of major firms to hire new graduates and apply internal promotion not only for white collar employees also for blue collar employees in the 1960s,<sup>73</sup> and on-the-job training closely linked educational background became a persistent personnel policy in Japanese firms.<sup>74</sup> More investment in freshmen who had just graduated high school at Kamaishi was a part of this prevailed trend.

This analysis of the micro data is consistent with the story “dual” labor market of the Japanese manufacturing in the macroeconomic context: Better educated graduates get into major firms, and, while internal labor market was dominant among major factories with advanced technologies such as the Kamaishi Iron Works, it was not among small and medium sized firms. Better education and investment in firm-specific human capital brought higher wages. Once an employee left a major firm, he could get only in small or medium sized firms with lower technology that paid worse. The quasi-rent provided employees of major firms with strong incentives to commit to internal labor market. This structural feature is thought to have emerged in the 1920s and had been persistent in the 1980s.<sup>75</sup>

As manufacturing firms began to form internal labor market with modernization effort,

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pp. 526-535.). Katz and Revenga (1989) suggests that it was at least partly because high school graduates in the Japanese manufacturing were better adjusted to technological changes with support from on-the-job-training enhanced in Japanese firms (Katz and Revenga (1989), p. 545.), which is a consistent with the result that relative importance of tenure over total experience is larger in Japan (Abe (2000), p. 264.).

<sup>68</sup>This possible story is consistent with the theoretical prediction such as Kiley (1999), pp. 712-720.

<sup>69</sup>Goldin and Katz (1998), pp. 726-727.

<sup>70</sup>Burdett and Smith (2002), p. 1450.

<sup>71</sup>Broadberry (1994), pp. 292-295.

<sup>72</sup>Doeringer and Piore (1971), pp. 43-48. Baker and Holmstrom (1995), p. 256.

<sup>73</sup>Gordon (1985), pp. 386-411. Sugayama (2011), pp. 338-443.

<sup>74</sup>Higuchi (1994), pp. 172-174.

<sup>75</sup>Ujihara (1966), pp. 402-425. Chuma (1998), p. 262. Ishikawa (2001), pp. 241-282. Odaka (2003), pp. 126-136. The more educated, the longer tenure is still the dominant principle among large Japanese firms. Ono (2010), pp. 13-17. As a heritage of the structure, for instance, “sheepskin” effect is much smaller in small firms. Bauer et al. (2005), pp.

the government increased investment in public education. Workers invested in general human capital at schools and short-term employment, and in firm-specific human capital in internal labor market. The society-wide transition to this direction formed divided labor market, and this structural feature of the labor market can be seen even in micro data.

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**Table 1** Employee numbers, years of schooling, and previous experience across cohorts.

Year joined	Number of employees who joined	Number of observations	Years of schooling (yos)				Years of previous experience (pvr)			
			maximum	minimum	median	mean	maximum	minimum	median	mean
yj1928	1	24	9	9	9	9.00	3	3	3	3.00
yj1929	1	38	8	8	8	8.00	1	1	1	1.00
yj1930	1	28	8	8	8	8.00	2	2	2	2.00
yj1931	0	0	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
yj1932	0	0	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
yj1933	3	81	8	8	8	8.00	5	2	2	2.85
yj1934	2	56	8	6	6	6.82	11	5	5	7.46
yj1935	5	141	8	8	8	8.00	9	1	1	3.96
yj1936	7	152	8	8	8	8.00	9	1	6	6.36
yj1937	7	193	8	6	8	7.75	12	1	8	6.55
yj1938	18	495	8	6	8	7.51	13	0	6	5.44
yj1939	39	1,010	9	6	8	7.91	13	0	5	5.21
yj1940	41	1,053	8	6	8	7.81	12	0	6	5.54
yj1941	44	998	9	6	8	7.85	13	0	4	4.80
yj1942	29	651	9	6	8	7.62	16	0	3	4.57
yj1943	23	522	9	6	8	7.98	14	0	2	3.87
yj1944	26	564	8	6	8	7.60	16	0	2	4.47
yj1945	17	376	8	6	8	7.77	3	0	1	0.89
yj1946	17	344	8	6	8	7.75	22	0	1	3.70
yj1947	11	203	8	6	8	7.82	3	0	1	0.98
yj1948	283	5,298	16	6	8	8.13	23	0	9	9.48
yj1949	259	4,532	15	6	8	8.09	21	0	8	8.55
yj1950	37	609	12	6	9	8.39	26	0	2	5.74
yj1951	53	857	15	6	8	7.76	21	2	9	9.36
yj1952	7	104	9	6	8	7.82	10	5	7	7.33
yj1953	13	154	12	9	9	9.16	4	0	3	2.77
yj1954	19	220	12	9	9	9.82	3	0	3	2.30
yj1955	11	122	9	9	9	9.00	3	2	3	2.88
yj1956	91	910	15	6	9	8.93	20	0	7	7.33
yj1957	69	620	15	6	9	9.08	18	0	6	6.75
yj1958	25	189	9	9	9	9.00	9	2	3	3.10
yj1959	87	586	12	8	9	10.05	15	0	3	3.83
yj1960	47	250	12	9	9	10.11	28	0	3	4.84
yj1961	35	148	12	9	9	9.16	12	1	3	3.82
yj1962	84	279	12	8	12	10.70	9	0	2	1.92
yj1963	41	71	15	6	8	8.70	35	2	20	19.51
yj1964	15	71	15	6	8	8.70	35	2	20	19.51
yj1965	9	29	12	8	12	10.72	5	1	1	2.28
yj1966	10	20	12	12	12	12.00	2	0	1	0.95
yj1967	8	15	12	9	9	10.20	14	1	5	7.40
total	1,495	22,013								

Notes : Previous experience: Years after graduating school, before employed by the firm.

**Table 2** Cohort effect in panel estimations.

	2-1			2-2		
Estimation method	panel least squares					
Dependent variable	log(rw)					
Cross-section	pooled (no cross-section dummy)					
Period (year)	fixed (year dummies inserted)					
Independent variables	coefficient	t statistic	probability	coefficient	t statistic	probability
c	-0.3643	-18.0062	0.0000	-0.2349	-9.7127	0.0000
log(yos)	0.1785	26.2363	0.0000	0.1828	27.1514	0.0000
log(epr)	0.2175	85.1986	0.0000	0.2444	84.4775	0.0000
log(ten)	0.0356	13.1963	0.0000			
yj1928-1929	0.6802	30.3373	0.0000	-0.1048	-1.4048	0.1601
yj1930-1931	0.6972	25.1817	0.0000	-0.0351	-0.4159	0.6775
yj1932-1933	0.6147	30.7214	0.0000	-0.0795	-1.2426	0.2140
yj1934-1935	0.6670	39.1088	0.0000	-0.0924	-1.6770	0.0936
yj1936-1937	0.6295	40.1487	0.0000	-0.0815	-1.6164	0.1060
yj1938-1939	0.6341	44.3434	0.0000	-0.0899	-1.9786	0.0479
yj1940-1941	0.5896	42.3080	0.0000	-0.0898	-2.1161	0.0343
yj1942-1943	0.5479	39.5355	0.0000	-0.0658	-1.6606	0.0968
yj1944-1945	0.4828	35.2916	0.0000	-0.0991	-2.6911	0.0071
yj1946-1947	0.4485	32.4434	0.0000	-0.1235	-3.5827	0.0003
yj1948-1949	0.4336	34.2090	0.0000	-0.0557	-1.8772	0.0605
yj1950-1951	0.3628	28.6223	0.0000	-0.0817	-2.9965	0.0027
yj1952-1953	0.3265	23.1302	0.0000	-0.0431	-1.5500	0.1212
yj1954-1955	0.3004	22.3837	0.0000	-0.0033	-0.1311	0.8957
yj1956-1957	0.1744	14.5807	0.0000	-0.1139	-5.9023	0.0000
yj1958-1959	0.1253	10.3818	0.0000	-0.0738	-4.1333	0.0000
yj1960-1961	0.0865	6.8358	0.0000	-0.0634	-3.4739	0.0005
yj1962-1963	0.1120	9.0093	0.0000	0.0287	1.5465	0.1220
yj1964-1965	0.0081	0.5814	0.5610	-0.0077	-0.2447	0.8067
yj1966-1967	0.1772	7.5325	0.0000	0.2381	3.6260	0.0003
yj1928-1929×log(ten)				0.0214	8.8438	0.0000
yj1930-1931×log(ten)				0.0198	6.2121	0.0000
yj1932-1933×log(ten)				0.0218	9.7056	0.0000
yj1934-1935×log(ten)				0.0269	13.8477	0.0000
yj1936-1937×log(ten)				0.0267	14.7740	0.0000
yj1938-1939×log(ten)				0.0306	18.0433	0.0000
yj1940-1941×log(ten)				0.0309	18.2999	0.0000
yj1942-1943×log(ten)				0.0301	17.4422	0.0000
yj1944-1945×log(ten)				0.0318	18.0134	0.0000
yj1946-1947×log(ten)				0.0360	19.1470	0.0000
yj1948-1949×log(ten)				0.0338	20.2743	0.0000
yj1950-1951×log(ten)				0.0357	19.9709	0.0000
yj1952-1953×log(ten)				0.0342	13.8339	0.0000
yj1954-1955×log(ten)				0.0322	13.3066	0.0000
yj1956-1957×log(ten)				0.0398	20.4086	0.0000
yj1958-1959×log(ten)				0.0363	14.3649	0.0000
yj1960-1961×log(ten)				0.0349	9.4968	0.0000
yj1962-1963×log(ten)				0.0242	4.4991	0.0000
yj1964-1965×log(ten)				0.0322	3.2872	0.0010
yj1966-1967×log(ten)				0.0197	0.6700	0.5029
year dummies	yes			yes		
cross-sections included	1,490			1,490		
periods included (years)	41 (1929-1969)			41 (1929-1969)		
included observations	22,045			22,045		
adjusted R <sup>2</sup>	0.9622			0.9631		
F statistic	8,911.6042	0.0000		7,016.7697		0.0000

**Table 3** Wage regressions: individual effects of in-house training programs.

	3-1			3-2			3-3			3-4		
Estimation method	panel generalized least squares											
Dependent variable	log(rw)											
Cross-section	random effect											
Period (year)	pooled (no year dummies inserted)											
Independent variables	coefficient	t statistic	probability	coefficient	t statistic	probability	coefficient	t statistic	probability	coefficient	t statistic	probability
c	-4.4206	-49.4743	0.0000	-6.7700	-46.2059	0.0000	-16.5632	-27.1311	0.0000	-11.0425	-10.0826	0.0000
log(hgt)							2.4108	19.3716	0.0000	0.7652	3.3674	0.0008
log(yos)	1.6045	39.8490	0.0000	2.6959	40.0987	0.0000	1.5915	43.3703	0.0000	2.8583	41.6628	0.0000
psw	0.4504	45.3885	0.0000	0.3973	39.9456	0.0000	0.3858	38.6450	0.0000	0.3645	36.4727	0.0000
log(epr)	0.4876	67.0161	0.0000	2.0288	26.3525	0.0000	0.3922	47.7746	0.0000	-2.8090	-4.2099	0.0000
log(ten)	1.4919	40.2076	0.0000	0.6148	10.7650	0.0000	6.5071	25.4012	0.0000	7.9548	16.9729	0.0000
log(hgt)×log(epr)										0.9674	7.1277	0.0000
log(hgt)×log(ten)							-0.9496	-18.3988	0.0000	-1.4063	-14.9899	0.0000
log(yos)×log(epr)				-0.7241	-20.1249	0.0000				-0.7811	-21.7663	0.0000
log(yos)×log(ten)				-0.1173	-4.3037	0.0000	-0.5635	-37.1927	0.0000	-0.1581	-6.5884	0.0000
dcy	-0.4035	-3.4469	0.0006	-0.3557	-19.6829	0.0000	-0.2755	-2.9906	0.0028	-0.3143	-3.4693	0.0005
dcy×log(ten)	0.1640	3.3196	0.0009	0.1547	20.2078	0.0000	0.1046	2.7320	0.0063	0.1167	3.0809	0.0021
sy	-0.3545	-19.3835	0.0000	-0.4288	-3.7114	0.0002	-0.2859	-18.8036	0.0000	-0.2860	-19.1205	0.0000
sy×log(ten)	0.1529	19.8530	0.0000	0.1742	3.5556	0.0004	0.1066	17.2821	0.0000	0.1061	17.3921	0.0000
dct	-0.2782	-8.4644	0.0000	-0.2607	-8.0229	0.0000	-0.1861	-5.5985	0.0000	-0.2033	-6.2165	0.0000
dct×log(ten)	0.0861	6.5971	0.0000	0.0834	6.4294	0.0000	0.0827	6.1054	0.0000	0.0872	6.5091	0.0000
dc	0.2875	16.9174	0.0000	0.3410	20.0529	0.0000	0.3885	28.3333	0.0000	0.4665	33.4297	0.0000
dc×log(ten)	-0.1194	-14.9293	0.0000	-0.1311	-16.5164	0.0000	-0.2084	-31.7769	0.0000	-0.2280	-34.8976	0.0000
cross-sections included	1,495			1,495			1,190			1,190		
periods included (years)	41(1929-1969)			41(1929-1969)			31(1939-1969)			31(1939-1969)		
included observations	22,126			22,126			15,774			15,774		
adjusted R <sup>2</sup>	0.7153			0.7179			0.8495			0.8530		
F statistic	4,276.9504			4,023.7014			5,937.5240			5,385.5983		



**Table 4** Interaction of education and tenure/previous experience.

		4-1		
Estimation method		panel generalized least squares		
Dependent variable		log(rw)		
Cross-section		random effect		
Period (year)		pooled (no year dummies inserted)		
Independent variables		coefficient	t statistic	probability
	c	0.2786	7.5211	0.0000
	log(yos)	0.4701	26.6533	0.0000
	log(pvr)	-0.0552	-7.0511	0.0000
	log(ten)	0.3021	25.7110	0.0000
	yj1928-1929×log(yos)×log(pvr)	-0.0762	-2.1206	0.0340
	yj1930-1931×log(yos)×log(pvr)	-0.0721	-1.1802	0.2379
	yj1932-1933×log(yos)×log(pvr)	-0.0547	-2.3141	0.0207
	yj1934-1935×log(yos)×log(pvr)	0.0394	3.8687	0.0001
	yj1936-1937×log(yos)×log(pvr)	0.0647	8.3687	0.0000
	yj1938-1939×log(yos)×log(pvr)	0.0679	12.9928	0.0000
	yj1940-1941×log(yos)×log(pvr)	0.0725	15.1548	0.0000
	yj1942-1943×log(yos)×log(pvr)	0.0878	17.3301	0.0000
	yj1944-1945×log(yos)×log(pvr)	0.0751	13.4498	0.0000
	yj1946-1947×log(yos)×log(pvr)	0.0698	10.9268	0.0000
	yj1948-1949×log(yos)×log(pvr)	0.1052	29.0775	0.0000
	yj1950-1951×log(yos)×log(pvr)	0.0911	22.8328	0.0000
	yj1952-1953×log(yos)×log(pvr)	0.1001	15.9854	0.0000
	yj1954-1955×log(yos)×log(pvr)	0.0917	14.0185	0.0000
	yj1956-1957×log(yos)×log(pvr)	0.0608	16.6241	0.0000
	yj1958-1959×log(yos)×log(pvr)	0.0392	9.5487	0.0000
	yj1960-1961×log(yos)×log(pvr)	0.0353	7.9487	0.0000
	yj1962-1963×log(yos)×log(pvr)	0.0168	3.1449	0.0017
	yj1964-1965×log(yos)×log(pvr)	0.0702	11.4393	0.0000
	yj1966-1967×log(yos)×log(pvr)	0.0443	5.0681	0.0000
	yj1928-1929×log(yos)×log(ten)	0.0441	3.3562	0.0008
	yj1930-1931×log(yos)×log(ten)	0.0421	1.9443	0.0519
	yj1932-1933×log(yos)×log(ten)	0.0366	3.3057	0.0009
	yj1934-1935×log(yos)×log(ten)	0.0087	1.1667	0.2433
	yj1936-1937×log(yos)×log(ten)	-0.0118	-1.7443	0.0811
	yj1938-1939×log(yos)×log(ten)	-0.0095	-1.6184	0.1056
	yj1940-1941×log(yos)×log(ten)	-0.0193	-3.3376	0.0008
	yj1942-1943×log(yos)×log(ten)	-0.0316	-5.4193	0.0000
	yj1944-1945×log(yos)×log(ten)	-0.0318	-5.4001	0.0000
	yj1946-1947×log(yos)×log(ten)	-0.0343	-5.6775	0.0000
	yj1948-1949×log(yos)×log(ten)	-0.0732	-13.2852	0.0000
	yj1950-1951×log(yos)×log(ten)	-0.0726	-12.7004	0.0000
	yj1952-1953×log(yos)×log(ten)	-0.0931	-13.9681	0.0000
	yj1954-1955×log(yos)×log(ten)	-0.0943	-15.2773	0.0000
	yj1956-1957×log(yos)×log(ten)	-0.0914	-16.3870	0.0000
	yj1958-1959×log(yos)×log(ten)	-0.1022	-17.7993	0.0000
	yj1960-1961×log(yos)×log(ten)	-0.1132	-17.7019	0.0000
	yj1962-1963×log(yos)×log(ten)	-0.1106	-16.0659	0.0000
	yj1964-1965×log(yos)×log(ten)	-0.0777	-8.1543	0.0000
	yj1966-1967×log(yos)×log(ten)	-0.1435	-9.5139	0.0000
	dcy, sy, dct, dc	yes		
	dcy×log(ten), sy×log(ten), dct×log(ten), dc×log(ten)	yes		
	interaction of year dummy and yos: dy×yos	yes		
	cross-sections included	1,490		
	periods included (years)	41(1929-1969)		
	included observations	22,045		
	adjusted R <sup>2</sup>	0.9652		
	F statistic	6,717.5996		0.0000

**Appendix** List of variables.

variable	definition
rw	real daily wage.
hgt	height when employed by the firm.
yos	years of schooling.
psw	postwar education generation (12 years old or younger in 1947). dummy variable
epr	experience in the labor market: $\text{age} - (5 + \text{yos}) + 1$ .
pve	previous experience: $\text{age} - (5 + \text{yos} + \text{ten}) + 1$ . Note: Every sample emolvee was hired by the firm in the last vear of his record.
yj19XX	dummy of year joined: =1 if joined the firm in 19XX. dummy variable
yj19XX-19YY	dummy of year joined: =1 if joined the firm from 19XX to 19YY. dummy variable
dy19XX	year dammy. dummy variable
ten	tenure: $(\text{years after employed by the firm}) + 1$ .
dcy	1 if completed Development Center for Youth (from 1927 to 1935). dummy variable
sy	1 if completed School for Youth (from 1935 to 1948). dummy variable
dct	1 if completed Development Center for Technician (from 1939 to 1973). dummy variable
dc	1 if completed Development Center (from 1946 to 1973). dummy variable