Schooling, employer learning, and internal labor market effect: Wage dynamics and human capital investment in the Japanese steel industry, 1930-1960s

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Abstract

Schooling, an observable signal, decreases its impact on wages as employers "publicly" learn workers' true types from workers' experience in the market. This symmetric employer learning hypothesis has been empirically questioned as, first, current and potential employers in fact asymmetrically learn, and second, complementarity between schooling and work experience could enshroud learning effect. Microanalysis of Japanese steel industry shows, 1) experience before entering the long-term employment is complementary to schooling, 2) employer learning effect dominates the complementarity effect after workers' joining the long-term employment. It suggests that previous evidences of employer learning have in fact captured 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' asymmetric learning and employees' human capital investment

While human capital of individual workers are hard to observe, educational background is one of 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.[1] 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.[2] Inspired by the screening hypothesis, rich empirical results supporting "sheepskin effects" of schooling have been presented for the US and other several economies.[3] 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,[4] it does not necessarily contradict with screening hypothesis. Schooling works as a strong signal as well as increases productivity. It has been established that "sheepskin effects" exist in someway in all of developed, developing, and even planed 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" hypothesis focuses on how "sheepskin" effect decreases as employers learn workers' types. 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 supporting it, the

[1]While the founders of "education as screening" hypothesis assumed education just as a screening device for simplification, 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.

[2]Stigler (1962), pp. 100-101.

[3]For the US, Riley (1979), pp.s240-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, and Bitzan (2009), pp. 761-764. Hansen, Weisbrod and Scanlon (1970), pp. 411-416, also gives some evidences that composed a part of screening hypothesis. For Japan, Bauer, Dross and Haisken-DeNew (2005), pp. 323-331. For the UK, McGuinnes (2003), pp. 599-606, and Silles (2008), pp. 218-219. For Canada, Ferrer and Riddell (2008), pp. 885-902, Ferrer and Riddell (2002), pp. 191-211, and Caponi and Plesca (2009), pp. 1113-1124. For Spain, Pons and Blanco (2005), pp. 336-343, and Pons (2006), pp. 144-151. For Czech, a transition economy, Münich, Svejnar and Terrell (2005a), pp. 104-119, and Münich, 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.

[4]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.

employer learning model established by Farber and Gibbons (1996) and Altonji and Pierret (2001) provides a clear prediction that impact of schooling on wage decreases over workers' experience in the labor market as employers "publicly" learn workers' types hidden at the time when they join the competitive labor market. This learning effect is in estimation practice captured by non-increasing coefficient of the interaction term of schooling and experience in a wage regression, and their empirical results support the prediction quite well, followed by supporting works about the US labor market.[5]

At the same time, this symmetric version of employer learning hypothesis has been empirically contested by mainly two strands.

The first one is reality of asymmetry in employer learning. A simple, but not negligible feature of 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 goes through "publicly," or, symmetrically between incumbent employer and entrant employers, and that interaction between schooling and experience in principle do not change before and after workers are successfully employed by a large firm that commits to long-term employment. The symmetric learning assumption is questioned by Pinkston (2009), which shows the US data in fact incumbent employers are learning better than entrant employers.

The other issue discussed is about workers' attitude to human capital investment. 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 is sufficiently weak to be dominated by the employer learning effect.[6] If non-increasing coefficient of interaction between schooling and experience observed, then complementarity between schooling and work experience is sufficiently weak, which does not seem to always hold under technology-skill/education complementarity. Indeed, Bauer and Haisken-DeNew (2001) showed that interaction term between schooling and work experience has significantly positive coefficient for the German data set and concluded that employer learning is not observed in the German labor market. While Lluis (2005) then found some evidence of employer learning in the German data set, the effect of employer learning seems to be weaker than that in the US. The extent of complementarity between schooling and worker experience is largely affected by the extent of human capital specificity, which is easily expected to be diverse over economies.

These two suggested questions indicate that the employer learning effect and the complementarity between general knowledge taught at schools and general human capital invested in workplaces differ over economies and this could be a key of comparative analysis of the labor market and the firm organization.

The employer learning model and suggested questions are, of course, not necessarily exclusive to each other. Let us depict a possible life course of a worker.

As Gathmann and Schönberg (2010) clearly demonstrates, based on a German data set, young workers are expected to typically invest in "portable" general human capital as switch-

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

[6]Farber and Gibbons (1996), p. 1017.

ing jobs several times in their early stages of career, and then enter employment of long-term basis.[7] Also in the US, especially when job changes are separated into voluntary ones and involuntary ones, it is a typical phenomenon that younger male workers voluntarily switches their jobs more frequently also in the US.[8]

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.[9] Rather, 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. Thus schooling and experience might be complements in work experiences of short-term basis. This effect would work to make coefficient of interaction term between schooling and work experience in a wage regression 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,[10] which might be less complementary to schooling, an opportunity of investment in general human capital. If complementarity between schooling and industry- and/or firm-specific skill is sufficiently weak to be dominated by the employer learning effect, then the interaction term between schooling and tenure in the firm is expected to have non-increasing coefficient over time.

While the employer learning model is entitled as a "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.

However, it does not devalue the importance of testing employer learning. Informational structure in the labor market varies over economies and human capital specificity does too. Degree of asymmetry and relative efficacy of employer learning captures these two critical dimensions of diversity in labor markets. Employer learning effect is an interesting focal point of comparative analysis on diversified labor markets.

[7] Gathmann and Schönberg (2010), pp. 10-36.

[8] Markey and Parks (1989), pp. 7-9. Parado, Caner and Wollf (2007), pp.445-447.

[9] Fallon and Layard (1975), p. 295. Goldin and Katz (1998), pp.710-723.

[10] Based on the NLSY, Parent (2000), pp. 308-320, shows that industry-specificity has larger impact on wages 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 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.

Succeeding close interest in the classical employer learning model, Galindo-Rueda (2003), Schönberg (2007), Pinkston (2009) are conscious of a possible asymmetry in employer learning and thus in 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 Lluis (2005) inquire 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, 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 candidate when a firm knows necessary skills well and the skills are complementary to each other and/or firm-specific.[11]

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 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 as typically in steel, petroleum refineries, paper mills, and so on.[12] 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.[13]

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 drives wage dynamics irrelevantly 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 between employer and employee. Thus it is expected that wages do not depart market from the market price equal to marginal productivity in the long term on average,

[11] Doeringer and Piore (1971), pp. 1-7. Williamson, Wachter and Harris (1975), pp. 269-277. Milgrom and Roberts (1992), pp. 358-385.

[12] Doeringer and Piore (1971), pp. 6, 50-51, 58.

[13] Goldin and Katz (1998), pp. 707-716.

though they are not necessarily one-to-one equal in the short term.[14]

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 have continuously managed long-term employment,[15] 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.[16] 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 markets in 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 originally pointed out by the radical economists and then redefined as transition to a more efficient second best organization by new institutional economists.[17] Such a transition would proceed with technological transformation that provides firms with informational advantages in acquisition of relevant human capital, which makes direct control by the firm relatively efficient.

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.[18] As with in the American steel industry,[19] it was the core in the transition to frame a work organization with systematic wage and promotion scheme.

This research deals with wage growth of blue-collar employees from 1929 to 1969 of the Kamaishi Iron Works,[20] a leading iron works then in Japan, and approaches to employer learning and human capital specificity in wage dynamics during formation of internal labor

[14] 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.

[15] 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.).

[16] 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.

[17] Marglin (1974), pp. 60-81. Stone (1974), pp. 128-147. Williamson (1985), pp. 206-239.

[18] In the case of department of maintenance, the Kamaishi Iron Works, intangible knowledge that had bee 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.

[19] Novack and Perlman (1962), pp. 339-347. Stone (1974), pp. 128-136. Williamson (1985), pp. 234-236.

[20] belonged to Fuji Iron and Steel Corporation then, now belongs to Nippon Steel Corporation.

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

Here we briefly review the classical employer learning model to make that fit to random effect estimation. Consider a random effect model of panel least square regression of the ith employee's wage (w) at time t (i=1, …, n),

$$w_{i,t} = \alpha_0 + \alpha_1 \mathrm{yos}_i + \alpha_2 \mathrm{yos}_i \times t + \alpha_3 t + \zeta_i + \epsilon_{i,t}, \tag{1}$$

where yos_i stands for years of schooling that is observable to employer and stochastic ζ_i captures time-invariant characteristics unobserved by the employer.

And put

$$\varDelta_t w_{i,t} = \alpha_2 \mathrm{yos}_i + \alpha_3 + \varDelta_t E(\zeta_i \mid \mathrm{yos}_i, t-1) + \varDelta_t \epsilon_{i,t} \equiv \alpha_2 \mathrm{yos}_i + \alpha_3 + \varphi_{i,t}, \tag{2}$$

where $\varDelta_t \epsilon_{i,t}$ is serially independent innovation and $\varphi_{i,t}$ is aggregate shock in the tth year.

Then inference based on the "public" employer learning model by Farber and Gibbons (1996) and Altonji and Pierret (2001) brings a straightforward prediction as a benchmark.[21] Linear projection of $w_{i,t}$ gives

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

$\mathrm{Cov}(w_{i,t}, \mathrm{yos}_{i,t})$ contains two-dimensional effect of cross-sectional one over workers $i = 1, \ldots, n$ and longitudinal over period t.

First, if schooling and experience are complements ($\partial^2 y/(\partial \mathrm{yos} \partial \tau) > 0$), then

$$\mathrm{Cov}_i(\varphi_\tau, \mathrm{yos} \times \tau) > 0,$$

and otherwise

$$\mathrm{Cov}_i(\varphi_\tau, \mathrm{yos} \times \tau) \leq 0,$$

for each τ ($\tau = 2, \ldots, t$). It says that covariance between φ and $\mathrm{yos} \times t$ should be positive in the cross-sectional dimension of workers $i = 1, \ldots, n$ if schooling and experience are complements and non-positive otherwise for each period t.

[21] Farber and Gibbons (1996), pp. 1010-1018. Altonji and Pierret (2001), pp. 316-323.

Second, if employers have learned employees' characteristics hidden when recruiting, which is captured by ζ_i, then there exists some $\bar{t}$ such that $\Delta_t E(\zeta_i \mid \mathrm{yos_i}, t-1)$ is decreasing in $t \leq \bar{t}$ and $\Delta_t E(\zeta_i \mid \mathrm{yos_i}, t-1) = 0$ for $t > \bar{t}$. Then $\mathrm{Cov}_t(\varphi_i, \mathrm{yos}_i \times t)$ is decreasing in $t \leq \bar{t}$ and $\mathrm{Cov}_t(\varphi_i, \mathrm{yos}_i \times t) = 0$ for $t > \bar{t}$ for each i. It states that covariance between φ_i and $\mathrm{yos}_i \times t$ is decreasing for $t = \bar{t}$ and 0 for $t > \bar{t}$ in the longitudinal dimension over t for each individual worker i.

Suppose that wages, with marginal productivity, increase over experience and standardize variables by taking logarithmic specification.[22] 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 learning, then $\hat{\alpha}_2$ is expected to be negative.[23]

(b) If schooling and experience are complements and the the effect of complementarity dominates that of 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.[24] It is also doomed that employer learning progresses fast especially in the first few years.[25]

2.2 Asymmetric learning, employees' incentives, and diversified labor markets

An interesting issue to improve learning model 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,[26] while Schönberg (2007) evaluates that the asymmetry is not so large as it affects the speed of employer learning.[27] About the UK, on the other hand, as Galindo-Rueda (2003) recognizes strong evidence of employer learning, it also finds

[22] While the standard wage estimation of Mincer style regresses 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.

[23] In the raw level term, non complementarity implies significantly zero of $\hat{\alpha}_2$. Under logarithmic specification, 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.

[24] Farber and Gibbons (1996), pp. 1023-1029. Altonji and Pierret (2001), pp.329-342. Lange (2007), pp. 4-7.

[25] Gibbons, Katz, Lemieux and Parent (2005), pp. 698-714. Lange (2007), pp. 9-19. A similar case in Germany is presented by Lluis (2005), pp. 745-755.

[26] Pinkston (2009), pp. 381-389.

[27] Schönberg (2007), pp. 672-678.

stronger learning effect of tenure, instead of total experience of workers, and asserts that incumbent employers have informational advantage in learning over entrant employers.[28] As later shown on **Table 4**, the same effect is clearly observed in the Japanese labor market.

Another point to be considered is specificity of human capital. The prediction of employer learning does not explicitly consider workers' dynamic decision making in human capital ivestment. 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.[29] 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. Children typically enrolled in assigned schools, graduated them, and finally made their own conscious decision when they chose workplaces.

Without particular constraints or distortions, 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. 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[30].

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 for young workers. That kind of commitment is necessary to entice workers invest in industry- and/or firm-specific human capital.[31]

The intensity of technology-skill/educatoin 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 work experience and did not recognize the employer learning effect,[32] Lluis (2005) succeeded in carefully mining some evidence of employer learning by controlling job-rank effects.[33] The German labor market appears to be modeled as friendly to investment in general human capital, compared with those in the US, the UK,[34] and Japan inquired by this research.

Diversity of labor markets consists of institutional framework that encourages human cap-

[28]Galindo-Rueda (2003), pp. 13-15.

[29]In addition, kids themselves tend to be ignorant about return of schooling as reported by Jensen (2010).

[30]Goldin and Katz (1996), pp. 253-256. Goldin and Katz (1998), pp. 698-719. Autor, Katz and Kearney (2006), pp. 190-191.

[31]Weinberg (2001), pp. 236-251.

[32]Bauer and Haisken-DeNew (2001), pp. 163-177.

[33]Lluis (2005), pp. 749-755.

[34]Galindo-Rueda (2003), pp. 8-17,

ital investment and informational structure that enables employers to learn workers' types. The coefficient of interaction term between schooling and experience is a tractable measure of employer learning. At the same time, the mesure also captures diversity of labor markets, which varies with institutions of human capital investment and informational structure about workers' types.

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 generally do not 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. On the other hand, 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 ith employee's experiences before and after he joined the firm that commits to internal labor market policy such as $t = \mathrm{epr} = \mathrm{pvr} + \mathrm{ten}$, where pvr is experience before he joined the case firm, ten is tenure at the firm, and epr is total experience. Then the wage regression equation (3) is reformulated as

$$\begin{aligned} w_{i,t} = \beta_0 &+ \beta_1 \mathrm{yos}_i \\ &+ \beta_2 \mathrm{yos}_i \times \mathrm{pvr} + \beta_3 \mathrm{yos}_i \times \mathrm{ten} \\ &+ \beta_4 \mathrm{epr} + \beta_5 \mathrm{ten} + \boldsymbol{\gamma}^T \boldsymbol{x_i} + \boldsymbol{\delta}^T \boldsymbol{x_i} \times \mathrm{ten} + \zeta_i + \epsilon_{i,t}, \end{aligned} \tag{4}$$

where $\boldsymbol{x_i}$ stands for time-invariant characteristics vector other than educational background.[35]

Taking logarithmic specification, 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 (*$\mathrm{yos} \times \mathrm{pvr}$*) 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 learning effect,*

and,

Prediction 2. *the interaction term between years of schooling and tenure after employed by the firm (*$\mathrm{yos} \times \mathrm{ten}$*) is expected to have negative coefficient (*$\hat{\beta}_3 < 0$*), which indicates that the*

[35]Bauer and Haisken-DeNew (2001), pp. 163-170, applies this formulation of regression on the German data to inquire whether employer learning goes "publicly" in the labor market (through workers' total experience) or "privately" (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), pp. 664-666, and Pinkston (2009), pp. 384-389, add tenure as regressors in the wage regression, to inquire possible difference in learning processes of incumbent and outside employers, and the latter emphasizes asymmetry between incumbent and entrant employers.

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.

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 integrated production of pig iron and 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.

Then, Japan entered the war against the US, and during the wartime isolation, Japanese steel industry turned out to be even more 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 steal 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, and now of 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 steal industry, sophisticated procedures of production were developed by employees and taught to younger employees by the elder. Since the 1950s, however, procedures of productions lines became manualized by better educated engineers, and the best practices at the shop floor came to be known to the firm.[36]

As a part of company wide investment plan, Fuji Iron and Steel decided to build a new state-of-the-art plant then named Tokai in Nagoya, now Nagoya 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.[37]

[36] Nakamura (2010), pp. 8-21.

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

3.2 The data

This research uses preserved 1,490 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 in selection and survival biases. Selection for relocation was handled under close dialogues and coordination between the firm and the union, and, in principle, anyone who was willing to move were allowed to be relocated. Thus, there was not a clear and intended measure to select employees for relocation.[38] 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 (*Ginosha 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.

[38] Umezaki (2010), pp.47-49.

- Short term programs (ex. elementary calculus).

(2) licenses the employee held.

(3) family composition.

(4) clinical history.

(5) basic wages.

(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**. The first and small peak of hiring 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 the second and highest peak is across from 1948 to 1951, when the Japanese economy began to recover from the wartime destruction. Then the last and small peak is around the late 1950s, when Japan began is rapid growth and the firm had not built new state-of-the-art iron works.

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 a typically 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 being employed by a large firm in the long-term basis, or starting 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 typically "Japanese firm," under which employees are recruited 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.[39] Difference of employees who graduated after 1947 is distributed mainly between the mandatory 9 yeas of elementary school (6 years) and junior high school (3 years) and the 12

[39] 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.

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).

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 more or less "shields" internal wage dynamics from the market price, then wage growth of each cohort could share common trend "shielded" 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,[40] though it does not imply that the wage dynamics deviates from 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), 2-year joined dummy such as $\mathrm{yj1928-1929}$, $\mathrm{yj1930-1931}$, $\mathrm{yj1932-1933}$, ..., and interaction between 2-year joined dummy and tenure such as $(\mathrm{yj1928}-1929)\times\mathrm{ten}$, $(\mathrm{yj1930}-1931)\times\mathrm{ten}$, $(\mathrm{yj1932}-1933)\times\mathrm{ten}$... 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 cohort effect be decreasing in tenure, interaction term of 2-year joined dummy and tenure ($\mathrm{yj}\times\mathrm{ten}$) is inserted as a regressor instead of tenure (ten).[41]

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.[42]

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.

As Baker et al. (1994b) describes, serial correlation of wage growth is another useful marker of internal labor market.[43] In the competitive market where wage increments are serially independent, coefficient of the first-lagged should be 1 in auto-regression of wage. If the firm "shields" wage determination from the market by some wage policy, the result would

[40] Baker et al. (1994b), pp. 923, 933-940. Baker and Holmstrom (1995), pp. 258-259.

[41] Our approach differs from Baker et al. (1994b) in some important points. In order to avoid identification difficulty and still to extract cohort effect, Baker et al. (1994b) assumes that tenure effect on wage growth is linear, 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, in this data set, as decreasing impact of past wage in the equation (6) below shows, tenure effect is not linear. 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.

[42] Umezaki (2010), pp. 42-51.

[43] Baker et al. (1994b), pp. 943-953.

different.

Auto regression with random effects of real wage ($\mathrm{rw}_{\mathrm{ten}}$), with years of education (yos_i) and year dummies inserted, gives,[44]

$$\log \mathrm{rw}_{\mathrm{ten}} = \underset{21.6217^{**}}{0.3424} - \underset{16.1141^{**}}{0.0080}\,\mathrm{yos} + \underset{354.7567^{**}}{0.8426}\,\log \mathrm{rw}_{\mathrm{ten}-1}, \tag{5}$$

where absolute value of the coefficient of lagged term ($\mathrm{rw}_{\mathrm{ten}-1}$) is smaller than 1, which means each history of wage is a contraction mapping.[45] If the shock of each year is serially independent innovation as the pure learning model of Farber and Gibbons (1996) assumes, the coefficient of lagged term should be 1, which is rejected by the equation (5). At the same time, the coefficient smaller than 1 of the equation (5) mentions that each wage history is heading for somewhere stationary, in a sense consistent of employer learning story over tenure.

Furthermore, a regression of real wage on more lagged terms gives with random effects and year dummies gives,[46]

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

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.[47]

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.

Following serial correlations seen on the equations (5) and (6), first, the sample employees are heterogeneous and there were "systematic winners and losers"[48] probably due to different ability of human capital accumulation,[49] and second, wage dynamics is on trajectory to some

[44]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^2: 0.9691. F-statistic: $15,706.8328^{**}$.

[45]It implies that extended growth curve of wage has unique fixed point.

[46]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**.

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

[48]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.).

[49]Baker et al. (1994b), p. 947.

steady state, which is supposed to be true value of the employee's "latent" ability, as pictured by descriptive formulation of Baker et al. (1994b). 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 [50]

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

However, this roughly monotonic trajectory is not necessarily the same over cohorts. **Table 3** regresses real wage $\mathrm{rw}_{\mathrm{ten}}$ on interaction terms of 2-year joined dummy and the 1st and 2nd lagged term such as $(\mathrm{yj}1928 - 1929) \times \log \mathrm{rw}_{\mathrm{ten}-1}$, $(\mathrm{yj}1930 - 1931) \times \log \mathrm{rw}_{\mathrm{ten}-1}$, $(\mathrm{yj}1932 - 1933) \times \log \mathrm{rw}_{\mathrm{ten}-1}$, ..., $(\mathrm{yj}1928 - 1929) \times \log \mathrm{rw}_{\mathrm{ten}-2}$, $(\mathrm{yj}1930 - 1931) \times \log \mathrm{rw}_{\mathrm{ten}-2}$, $(\mathrm{yj}1932 - 1933) \times \log \mathrm{rw}_{\mathrm{ten}-2}$, . Then the results obviously shows similar, but considerably and significantly different wage curves even between adjacent cohorts. This is exactly the feature of wage curves in a internal labor market Baker et al. (1994b) depicts profiles of mean wage over different cohorts.[51] It implies that we need to carefully control cohort effects to inquire **Prediction 1** and **Prediction 2** in the section 2.3 by estimating equation (4).

4 Empirical results

4.1 Overview: Tenure, employer 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) as a benchmark, to make it easier to compare this research with previous ones. **Table 4** gives results of random effect estimation regressing real wage (rw) on height when employed by the firm (hgt), years of schooling the employee had completed (yos), total experience in the labor market (epr), tenure at the firm (ten), interaction of height and experience ($\mathrm{hgt} \times \mathrm{epr}$), interaction of height and tenure ($\mathrm{hgt} \times \mathrm{ten}$), interaction of years of schooling and experience ($\mathrm{yos} \times \mathrm{epr}$), interaction of years of schooling and tenure ($\mathrm{yos} \times \mathrm{ten}$), 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 ($\mathrm{dcy} \times \mathrm{ten}$, $\mathrm{sy} \times \mathrm{ten}$, $\mathrm{dct} \times \mathrm{ten}$, $\mathrm{dc} \times \mathrm{ten}$).[52] 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 on productivity and wages,[53] 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

[50] Baker et al. (1994b), pp. 924, 926-927, 952-954.
[51] Baker et al. (1994b), pp. 933-935.
[52] Some samples lack the information of height, weight, and lung capacity.
[53] Oleopoulos (2005), pp. 158-170.

without controlling cohort effect. On **Table 4**, interaction terms of years of schooling both with experience after graduation ($\mathrm{yos} \times \mathrm{epr}$) and tenure ($\mathrm{yos} \times \mathrm{ten}$) have significantly negative coefficients in the models of 4-2 and 4-4. Negatively significant coefficient of $\mathrm{yos} \times \mathrm{ten}$ indicates that the current employer learned better than previous employers, as the American and the British cases.[54]

As well as years of schooling, a proxy of ability observable to the employer when recruited is physical characteristics such as height. Height is thought to sometime affect wages,[55] while the channel is still ambiguous especially for white-collar workers.[56] 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 were 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. Height is a good proxy of such physical strength. Again, also about height, the employer learning hypothesis holds. Interaction terms of height with tenure ($\mathrm{hgt} \times \mathrm{ten}$) has significantly negative coefficient in the models 4-3 and 4-4.

4.2 Schooling and in-house training programs

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

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 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 with tenure from the prewar programs ($\mathrm{dcy} \times \mathrm{ten}$, $\mathrm{sy} \times \mathrm{ten}$, $\mathrm{dct} \times \mathrm{ten}$) to the postwar program ($\mathrm{dc} \times \mathrm{ten}$) can be attributed to selection policy of Development Center (dc), which admitted only high school graduates since 1953. Closely linked to educational back ground, the effect of in-house training program also came to decrease over tenure as the employer learned types of employees hidden when recruited.

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 ($\mathrm{yos} \times \mathrm{ten}$, $\mathrm{hgt} \times \mathrm{ten}$) have significantly negative coefficients. Next we proceed to extraction of some information about interaction between employees' history before employed by the firm and wages.

[54]Pinkston (2009), pp. 384-387. Galindo-Rueda (2003), pp. 13-15.

[55]Hersch (2008), pp. 369-375.

[56]Kuhn and Weinberger (2005), pp. 418-420.

Now examine the equation (4) and the **Prediction 1** and **Prediction 2** in the section 2.3. The first approach of a straightforward specification without control of cohort effect is presented on **Table 5**. With changes of return on schooling controlled by inserting interaction between year dummy and schooling ($dy \times \mathrm{yos}$), interaction term between years of schooling and previous experience ($\mathrm{yos} \times \mathrm{pvr}$) has significantly positive coefficient, which violates employer learning hypothesis and supports **Prediction 1**, while interaction term between years of schooling and tenure ($\mathrm{yos} \times \mathrm{ten}$) has significantly negative coefficient that supports asymmetric learning hypothesis and **Prediction 2**.

Similar but different wage curves on (**Table 3**) urges us to control of cohort effects for robustness check of the results on **Table 5**. Therefore, **Table 6** presents a regression of real wage (rw) with random effects on years of schooling (yos), experience after graduation and before employed by the firm (pvr), tenure after employed by the firm (ten), and, inspired by the **Table 3**, interaction term of 2-year joined dummy, years of schooling and previous experience before employed by the firm ($(\mathrm{yj}1928-1929) \times \mathrm{yos} \times \mathrm{pvr}$, ...), interaction term of cohort dummy, years of schooling and tenure ($(\mathrm{yj}1928-1929) \times \mathrm{yos} \times \mathrm{ten}$, ...) to control cohort effects on interaction between schooling and work experience. **Table 6** also controls training programs (dcy, sy, dct, dc), interaction terms between training programs and tenure ($\mathrm{dcy} \times \mathrm{ten}$, $\mathrm{sy} \times \mathrm{ten}$, $\mathrm{dct} \times \mathrm{ten}$, $\mathrm{dc} \times \mathrm{ten}$), and interactions between year dummy and years of schooling ($\mathrm{dy} \times \mathrm{yos}$) to capture changes in return of schooling over the period.

Then, again, except for early cohorts up to the mid 1930s, interaction term between years of schooling and previous experience ($\mathrm{yos} \times \mathrm{pvr}$) has significantly positive coefficient, which violates the employer learning hypothesis and supports the **Prediction 1**, while interaction term between years of schooling and tenure ($\mathrm{yos} \times \mathrm{ten}$) has significantly negative coefficients also here, which supports asymmetric employer learning hypothesis as well as the **Prediction 2** in the section 2.3. The feature showed on **Table 5** was widely shared among most cohorts except for the early cohorts and its results are robust

An immediate interpretation of the results on **Table 5** and **Table 6**, 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 informed 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 the firm. This is a story consistent with the result.

While regression of wages on the interaction term between years of schooling and experience ($\mathrm{yos} \times \mathrm{epr}$) on **Table 4** suggests that employer learning holds, the results on **Table 5** and **Table 6** indicates that coefficient of the interaction term between years of schooling and experience ($\mathrm{yos} \times \mathrm{epr}$) could be divided into two effects of before and after employed by the firm ($\mathrm{yos} \times \mathrm{pvr}$, $\mathrm{yos} \times \mathrm{ten}$), whose coefficients' signs are opposite.

The classical employer learning hypothesis assumed small significance of complementarity between schooling and work experience in workers' young days, and "public" learning in the competitive labor market and (Farber and Gibbons (1996)). However, the result here shows first that learning effect does not dominate complementary effect of schooling and experience as workers invested in general capital in their early stages of career, which is the phenomenon observed even longer in the German case as clarified by Bauer and Haisken-DeNew (2001), and second that employer learning is asymmetric that goes much more effective, as the American and the British cases presented by Pinkston (2009) and Galindo-Rueda (2003), after workers join long-term employment instead of "publicly" going through in the competitive market. Interaction term between years of schooling and experience ($\mathrm{yos} \times \mathrm{epr}$) on **Table 4** appears to support employer learning, but it is not because the workers' ability came to be "publicly" learned in the market over total experience, but because the long-term employer learned much better after employees were incorporated to the internal labor market.

Indeed, coefficient of the interaction term between years of schooling and previous experience ($\mathrm{yos} \times \mathrm{pvr}$) is significantly positive, as that between years of schooling and experience after employed by the firm ($\mathrm{yos} \times \mathrm{ten}$) is significantly negative on **Table 5** and **Table 6**. Because the latter effect is large enough, it appears, coefficient of interaction between years of schooling and experience ($\mathrm{yos} \times \mathrm{epr}$) on **Table 4** is negative. In this sense, significantly negative coefficient of the interaction term between years of schooling and and experience ($\mathrm{yos} \times \mathrm{epr}$) 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 the classical employer learning hypothesis assumes learning is "publicly" going in the labor market, the corresponding empirical studies such as those based on the NLSY have not differentiated employer learning outside and within the firm (Farber and Gibbons (1996), Altonji and Pierret (2001)). However, recent results for the American and the British cases have suggested more inquiry focusing on current employers in learning (Pinkston (2009), Galindo-Rueda (2003)).

While the representative works of modern approach to the internal labor market does not provide clear answer to the mixed picture, which partly supports employer learning, on-the-job training, or comparative advantage hypotheses (Baker et al. (1994b), Gibbons et al. (2005), Lluis (2005)), this Japanese case seems to support the hypothesis of effective employer learning within internal labor markets suggested by Baker et al. (1994b).[57]

Generalization of the Japanese experience too much might not sound plausible. Some empirical evidences, however, indicate that long-term employment is seen and does have positive impact wages and job protection in the American workplaces, to encourage industry-, firm-, and/or skill-specific human capital.[58] In addition, since the 1930s, basic wages of American workers in fact have been even more shielded to exogenous demand shocks than Japanese

[57] Baker et al. (1994b), pp. 952-954.

[58] Hall (1980, 1982). Abe (2000), pp. 258-263. Weinberg (2001), pp. 236-251. Poletaev and Robinson (2008), pp. 400-413.

and British counterparts due to institutional settings of the labor market,[59] and some empirical results support the existence of implicit contract to shield wages from macroeconomic shocks in the US.[60]

Furthermore, exactly based on the 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 have completed on-the-job training with current employers have lower separation rate, as is expected in Japan.[61] 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 faster employer learning in early stages has succeeded in provision of concrete empirical studies in an intra-firm data set,[62] while a study based on the NLSY, which include mixed ingredients of employees who are already incorporated into long-term employment and yet to be, provides less clear result.[63] Also here in the intra-firm data set of Japanese steel industry, the faster employer learning the earlier stage principle is presented very clearly on **Table 6**, 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 ($\mathrm{yos} \times \mathrm{ten}$).

Along with the evidences, this case study suggests probability that existent empirical results to support the employer 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.

Obviously, the extent of asymmetry of employer learning and the extent of complementarity between schooling and experience could vary over economies. As Galindo-Rueda (2003), Schönberg (2007) and Pinkston (2009) together mention that employer learning goes a little more symmetrically in the US than in the UK.[64] 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).[65] If skill is perfectly standardized within each industry, 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 should be intrinsically complements.

Again, employer learning effect is a focal point of informational structure in the market and degree of human capital specificity. Compared with the previous evidences for the US,

[59] American firms seem to adjust workdays instead of basic wages to demand shocks. Gordon (1982), pp. 18-42.

[60] 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.

[61] Parent (1999), pp. 305-315.

[62] Lluis (2005), pp. 745-755.

[63] Gibbons et al. (2005), pp. 698-714.

[64] Galindo-Rueda (2003), pp. 13-15. Schönberg (2007), pp. 672-675, Pinkston (2009), pp. 381-389.

[65] Weinberg (2001), pp.236-247. Bauer and Haisken-DeNew (2001), pp.l66-177.

the UK, and Germany, the result of this research tentatively mentions that the Japanese labor market in the first 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 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.

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 Lluis (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 6 also shows that negativity of coefficient of interaction between years of schooling and tenure ($\mathrm{yos} \times \mathrm{ten}$) enlarges as cohort goes down. It indicates that employer learning went faster in the late periods. Since later cohorts had shorter tenure, the employer learning observed with later cohorts show employer learning in the early years after employees joined the firm. Lluis (2005) infers that learning effect had larger impact in earlier tenure in internal labor markets, based on the German data.[66] 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.[67]

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"[68] 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.[69] It directly led to supply of higher educated blue-collar workforce 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 4** means that return of schooling rather increased after the Second World War.[70]

[66] Lluis (2005), pp. 745-755.

[67] Goldin (2001), pp. 269-275. Ueshima, Funaba and Inoki (2006), pp. 72-73.

[68] Goldin (1998), p. 350.

[69] Godo and Hayami (2002), pp. 968-974.

[70] 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

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,[71] as happened in the US from the 1920s to the 1940s.[72] Also, massive ivestment in public education by the government apparently succeeded in release of the society from the "low skill trap" equilibrium.[73] 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.[74]

The Kamaishi Iron Works rode 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 ($\mathrm{yos} \times \mathrm{dc}$) on **Table 4** mentions.

While "port of entry," where only young workers are employed and are assigned to the lowest ladder, is a symbolic characterizaion of internal labor market suggested by Doeringer and Piore (1971), it is not always empirically supported.[75] 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,[76] and on-the-job training closely linked educational background became a persistent personnel policy in Japanese firms.[77] More investment in freshmen who had just graduated high school at Kamaishi was a part of the ongoing prevalence.

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 markets are dominant among major factories with advanced technologies such as the Kamaishi Iron Works, it is 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 hired only by small or medium sized firms with lower technology that paid worse. The quasi-rent provided employees of major firms

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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), 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.).

[71] This possible story is consistent with the theoretical prediction such as Kiley (1999), pp. 712-720.

[72] Goldin and Katz (1998), pp. 726-727.

[73] Burdett and Smith (2002), p. 1450.

[74] Broadberry (1994), pp. 292-295.

[75] Doeringer and Piore (1971), pp. 43-48. Baker and Holmstrom (1995), p. 256.

[76] Gordon (1985), pp. 386-411. Sugayama (2011), pp. 338-443.

[77] Higuchi (1994), pp. 172-174.

with strong incentives to commit to internal labor market. This structural feature is thought to have emerged in the 1920s and had still been persistent in the 1980s.[78]

As manufacturing firms began to form internal labor markets with modernization effort, 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 markets. The society-wide transition to this direction formed divided labor markets, and this structural feature of the labor market can bee seen even in micro data.

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[78] 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.

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Table 1 Emplyee 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)				Nationwide events
			max	min	median	mean	max	min	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	War effort
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	Reconstructior
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	Rapid growth began
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)					
Indepedent 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^2	0.9622			0.9631		
F statistic	8,911.6042		0.0000	7,016.7697		0.0000

Table 3 Cohort effect on wage curves

		3-1		
Estimation method		panel generalized least squares		
Dependent variable		$\log(rw_{ten})$		
Cross-section		random effect		
Period (year)		pooled (no year dummies inserted)		
Indepedent variables		coefficient	*t* statistic	probability
	c	0.5993	42.1125	0.0000
	log(yos)	0.0835	8.8833	0.0000
1st lagged	yj1928-1929×$\log(rw_{ten-1})$	0.3635	17.8422	0.0000
	yj1930-1931×$\log(rw_{ten-1})$	0.6119	10.0973	0.0000
	yj1932-1933×$\log(rw_{ten-1})$	0.6430	24.5980	0.0000
	yj1934-1935×$\log(rw_{ten-1})$	0.6212	33.6226	0.0000
	yj1936-1937×$\log(rw_{ten-1})$	0.6181	36.7199	0.0000
	yj1938-1939×$\log(rw_{ten-1})$	0.5742	63.8623	0.0000
	yj1940-1941×$\log(rw_{ten-1})$	0.5153	67.5934	0.0000
	yj1942-1943×$\log(rw_{ten-1})$	0.5256	49.6591	0.0000
	yj1944-1945×$\log(rw_{ten-1})$	0.4692	43.8440	0.0000
	yj1946-1947×$\log(rw_{ten-1})$	0.4556	29.9910	0.0000
	yj1948-1949×$\log(rw_{ten-1})$	0.4487	55.3832	0.0000
	yj1950-1951×$\log(rw_{ten-1})$	0.3405	18.5565	0.0000
	yj1952-1953×$\log(rw_{ten-1})$	0.2978	7.1952	0.0000
	yj1954-1955×$\log(rw_{ten-1})$	0.2119	4.9534	0.0000
	yj1956-1957×$\log(rw_{ten-1})$	0.4365	17.5345	0.0000
	yj1958-1959×$\log(rw_{ten-1})$	0.4276	8.1555	0.0000
	yj1960-1961×$\log(rw_{ten-1})$	0.4406	6.8294	0.0000
	yj1962-1963×$\log(rw_{ten-1})$	0.2941	4.2683	0.0000
	yj1964-1965×$\log(rw_{ten-1})$	0.3635	4.6177	0.0000
	yj1966-1967×$\log(rw_{ten-1})$	0.1089	0.4172	0.6765
2nd lagged	yj1928-1929×$\log(rw_{ten-2})$	0.3057	14.3565	0.0000
	yj1930-1931×$\log(rw_{ten-2})$	0.1016	1.6119	0.1070
	yj1932-1933×$\log(rw_{ten-2})$	0.0178	0.6614	0.5084
	yj1934-1935×$\log(rw_{ten-2})$	0.0597	3.1417	0.0017
	yj1936-1937×$\log(rw_{ten-2})$	0.0553	3.2076	0.0013
	yj1938-1939×$\log(rw_{ten-2})$	0.0951	10.7417	0.0000
	yj1940-1941×$\log(rw_{ten-2})$	0.1457	19.2960	0.0000
	yj1942-1943×$\log(rw_{ten-2})$	0.1268	11.8695	0.0000
	yj1944-1945×$\log(rw_{ten-2})$	0.1687	15.5359	0.0000
	yj1946-1947×$\log(rw_{ten-2})$	0.1729	11.7346	0.0000
	yj1948-1949×$\log(rw_{ten-2})$	0.1814	24.2104	0.0000
	yj1950-1951×$\log(rw_{ten-2})$	0.2669	14.3601	0.0000
	yj1952-1953×$\log(rw_{ten-2})$	0.2756	6.3033	0.0000
	yj1954-1955×$\log(rw_{ten-2})$	0.3388	7.4659	0.0000
	yj1956-1957×$\log(rw_{ten-2})$	0.0674	2.5942	0.0095
	yj1958-1959×$\log(rw_{ten-2})$	-0.0006	-0.0098	0.9922
	yj1960-1961×$\log(rw_{ten-2})$	-0.0541	-0.7810	0.4348
	yj1962-1963×$\log(rw_{ten-2})$	0.0200	0.2639	0.7918
	yj1964-1965×$\log(rw_{ten-2})$	-0.1670	-1.8511	0.0642
	yj1966-1967×$\log(rw_{ten-2})$	0.3378	1.0892	0.2761
	interaction of year dummy and yos: dy×yos	yes		
	cross-sections included	1,433		
	periods included (years)	39 (1931-1969)		
	included observations	19,066		
	adjusted R^2	0.9725		
	F statistic	8,537.2225		0.0000

Table 4 Wage regressions: indvidul effects of in-house trainng programs.

	4-1			4-2			4-3			4-4		
Estimation method	panel generalized least squares											
Dependent variable	log(rw)											
Cross-section	random effect											
Period (year)	pooled (no year dummies inserted)											
Indepedent 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^2	0.7153			0.7179			0.8495			0.8530		
F statistic	4,276.9504		0.0000	4,023.7014		0.0000	5,937.5240			5,385.5983		0.0000

Table 5 Interaction of schooling previous epxerience/tenure: without conrol of cohort effects.

	5-1		
Estimation method	panel generalized least squares		
Dependent variable	log(rw)		
Cross-section	random effect		
Period (year)	pooled (no year dummies inserted)		
Indepedent variables	coefficient	*t* statistic	probability
c	0.3202	5.4213	0.0000
log(yos)	0.3673	13.2674	0.0000
log(pvr)	-0.0588	-2.1843	0.0290
log(ten)	0.7052	47.9549	0.0000
log(yos)×log(pvr)	0.0684	5.4487	0.0000
log(yos)×log(ten)	-0.2185	-31.8333	0.0000
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^2	0.9545		
F statistic	10,279.0237		0.0000

Table 6 Interaction of schooling and previous epxerience/tenure: robustness check with control of cohort and other effects.

		6-1		
Estimation method		panel generalized least squares		
Dependent variable		log(rw)		
Cross-section		random effect		
Period (year)		pooled (no year dummies inserted)		
Indepedent 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
previous experience	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
tenure	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^2	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: age−(5+yos)+1.	
pve	previous experience: age−(5+yos+ten)+1. Note: Every sample emolvee was hired by the firm in the last year of his record.	
yj19XX	dummy of year joined: =1 if joined the firm in 19XX.	dummy variable
yj19XX-19YY	dummy of year joined: =1 ifjoined the firm from 19XX to 19YY.	dummy variable
dy19XX	year dammy.	dummy variable
ten	tenure: (years after employed by the firm)+1.	
dcy	1 if completed Development Center for Youth (from 1927 to 193	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	dummy variable
dc	1 if completed Development Center (from 1946 to 1973).	dummy variable