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Abstract

This paper analyzes the effects of inter-industry and firm size on wage differentials, focusing on how their estimated effects vary by the introduction of elements indicating firm characteristics such as wage-experience profiles. Using the worker-establishment matched data, we find that inter-industry effects are larger than firm size ones judging from their explanatory powers and the wage distributions caused by them although the introduction of firm characteristics reduces more the effect of industry. Since this paper is based on the efficiency wage hypothesis to explain wage differentials, it is required to test for the bonding critique. Checking how steeper wage profiles affect wages of young workers, we find that even those who work at firms where wage profiles are steeply rising are not paid lower. This result supports the efficiency wage hypothesis to be a good explanation for wage differentials.

JEL Classification: J31, J41

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1. Introduction

Previous studies on wage differentials generally show that industry and firm size play an important role in the determination of wages. The approach used most often is to estimate the effect of either variable in wage regressions, controlling for the other in addition to worker characteristics such as age, tenure, sex, and education, and then to check how their estimated coefficients and explanatory powers are in the estimation where the other variable is included. Interestingly, in so doing it has rarely questioned which variable is more crucial for explaining wage differentials.

This question is important particularly for two reasons. One is that both the effects of industry and firm size are explained by the similar factors such as ability to pay, rent-sharing, efficiency wages, non-wage job attributes, labor quality" and so on, as summarized in next section. Then, the problem of which, industry or firm size, more firmly captures such factors can arise. The other reason is that in reality firms directly determine wages, negotiating with workers in some cases, and hence the effects of industry and firm size come through their wage policies. In other words, since any industry or firm size can be attached to any firm, the effects of industry and firm size are fully nested within some effects of firms' characteristics. This aspect makes us strongly recognize that it is necessary to introduce firm characteristics such as wage policies into the estimations of industry and firm size effects.

We have three main aims in this paper. As implied above, the first one is to analyze how the effects of industry and firm size vary by the introduction of elements indicating the attributes and wage policies of firms into estimations. In particular, the effects of slopes of wage-experience profiles are focused on.

The second aim is to test the efficiency wage hypothesis, on which many researchers depend for explaining inter-industry and firm size effects on wage differentials. This hypothesis claims that firms raise not only the wage levels but also the steepness of wage profiles to deter worker shirking, to suppress worker quitting or to hire high-quality workers. It is assumed in our analysis that a firm has to pay a higher wage as its wage profile becomes more steeped and that the steepness indicates the importance of efficiency wage aspects for it.

The third aim is to investigate the effectiveness of the bonding critique to the efficiency wage hypothesis. It is criticized that since firms are assumed to determine efficiency wages without regard to labor market conditions, many workers will apply to firms paying high wages, and then their initial wages can decrease, clearing the labor market. This paper will test this criticism by analyzing the effect of steeper wage profiles on young workers' wages.

For our analysis we utilize worker-establishment matched data. This data set was obtained by matching the micro data from the "Wage Structure Basic Survey"(Ministry of Health, Labor and Welfare, 2000) with that from the "Employment Administration Survey for Female Workers"(Ministry of Health, Labor and Welfare, 2000) From the former we can get information on individual workers' wage, age, sex, tenure, education, occupation and industry, and from the latter the employment condition of individual establishments, for example, the number of employees, the ratio of female workers, that of part-timers and personnel hierarchical structure. Fortunately, since the number of observed workers in each establishment is more than twenty, we can estimate a wage function for each establishment using labor market experience as an explanatory variable and know the slope coefficient of its estimated wage profile. According to Calvo and Wellisz(1979), Lazear and Moore(1984), Malcomson(1984), Gibbons and Waldman(1999), for instance, the wage profile can be considered to represent eloquently the firm's wage policy concerning human investment, workers' incentive and the need for skilled workers.

This paper is organized as follows. In the section 2 previous studies on efficiency wages are summarized. Section 3 describes the data used and defines the variables. Section 4 discusses the results on the determinants of inter-industry and firm size wage differentials and interprets them. Section 5 discusses some problems concerning our approach which uses the wage profile of each firm as an explanatory variable. In Section 6 the contents of this paper are summarized.

2 Previous Studies

This section does not aim to comprehensively survey previous studies, but to show similarity in the interpretations concerning the effects of industry and firm size on wage differentials. That is, it will be discussed that explanations for them are the same in essence between industry and firm size although they slightly very to the extent that firms and industries are different. For example, according to Summers and Kruger(1988), industry shows how jobs differ in required skills and work circumstance, how it is difficult for firms to monitor workers' effort and how the product market is competitive. Note that these interpretations also hold in the different firm sizes.

To begin with, the monopoly power explanation proposed, for example, by Weiss(1966) and Mellow(1982) is traditionally prevalent. In more concentrated industries large firms enjoying greater monopoly power can earn more excess profits and may share those with workers. However, as discussed by Brown and Medoff(1989),this traditional and institutional explanation faces a difficult problem of explaining why profit-maximizing firms pay more than the market wages which make it possible to allure qualified workers but not overpaid in otherwise firms. One of the reasons why firms pay higher wages is provided by strong union power or threat of unionization. However, it is necessary for the union power hypothesis to explain why there are large differences even in industries with smaller threats or no possibility of unionization.

The traditional theory of equalizing differences in the labor market developed by Rosen(1985) considers that inter-industry wage differentials are compensating ones for non-wage job attributes such as working conditions and physical and mental hardness. Unfortunately, however, it seems not to be supported by empirical studies. For example, Kruger and summers(1986) shows that the inclusion of several working condition variables in a standard wage equation hardly affects the estimated industry wage premiums. Also in Japan Tachibanaki and Ohata(1994) and Tachibanaki(1996) find no evidence of compensating wage differentials among firms of different sizes, arguing that differences in compensations are enlarged in fringe benefits, as found by Freeman(1981)

According to Hamermesh(1980),the size-wage effect is caused by the fact that larger firms employ more skilled workers because they use more capital-intensive technology, and hence it is more efficient for them to hire workers with better skills. Oi(1983) also addressed that large firms tend to rely on more complex and state-of-the-art equipment and, hence, experience more frequent changes in equipment. These characteristics found in large firms predict a greater return to on-the-job training under the existence of complementarily between human capital and physical capital. Importantly, Hamermesh and Oi considered that the accumulated human capital cannot be fully captured by the traditional variables such as tenure and education and that firm-size can contribute to capturing the human capital more firmly.

The effects of Labor quality are also controversial in the discussions of industry effect as well as in firm size. In particular, Murphy and Topel(1987) find that about two-thirds of the wage premiums are caused by unobserved worker characteristics such as ability, but Krueger and summers(1988) and Gibbons and Katz(1992) argue, based on the longitudinal data on workers who switch jobs between industries, that true wage differentials exist across industries and that the effect of unobserved ability is limited.

In line with the efficiency wage hypothesis, Bulow and Summers(1986) and Garen(1985) address that technologies of monitoring the performance of employees can vary across firms of different sizes, that is, monitoring is more difficult in large firms, and, hence, they are in favor of higher wages and less monitoring. Krueger and Summers(1988) also relied on efficiency wages to explain why inter-industry wage differential are sizable and persistent, even after controlling for observed worker characteristics and union status. They stress the importance of monitoring difficulty among industries. However, as noted by Dickens and Katz(1987), inter-industry wage differentials are highly correlated across occupations. That is, when one occupation in the industry is highly paid, other occupations in this industry also tend to be highly paid.

Weiss and Landau(1984) analyzed recruitment and selection strategies of the firms which minimize the per unit cost of labor by manipulating a wage and a hiring standard under imperfect information on labor quality. In their model firms have to pay high wages to hire workers with high labor quality since there is a positive correlation between a worker's reservation wage and his labor quality. It is crucially assumed in their efficiency wage model that, as the number of new employees to be hired increases the number of applicants per vacancy decreases due to the limitation of available labor pool. This implies that firms employing a large number of workers are forced to pay high wages to satisfy the required level of hiring standard.

Montgomery(1991) and Lang(1991) developed recruiting models, which pay attention to costly search behaviors of firms for recruiting workers. They address that costs particularly produced by unfilled vacancies differ among firms such that the costs are larger for firms of which workers are productive due to high capital intensity or profitability, and hence they will offer higher wages to decrease the probability of their vacancies going unfilled. Thus inter-industry wage differentials can be persistent in the competitive labor market.

Recently, Zabojnik and Bernhardt(2001) presented a tournament model to explain for the observed size-wage effect and inter-industry wage differentials. They insist those firms, which are larger, more technology intensive, and more profitable, are able to provide more efficient incentives by corporate tournaments, thereby leading workers to accumulating more general human capital and to receiving higher wages.

As shown above, most of the recent interpretations on inter-industry and firm size effects depend on efficiency wage models to make their discussions reconcile more with the competitive theory[1]. Unfortunately, however, efficiency wage models are often too vague to test, as discussed by Manning(2003). Therefore, it is important for us to find appropriate variables indicating efficiency wage aspects more directly. Based on the discussions by Calvo and Wellisz(1979), Lazear and Moore(1984) and Malcomson(1984), we consider here that firms solve the efficiency wage problems not only by offering higher levels of wages but also manipulating slopes of wage profiles.

3 Data and Variables

As mentioned in Section 1, one of the major aims in this paper is to explicitly take account of the effect of firm characteristics on wage levels. Due to data limitation, at least in Japan, it has been difficult for us to simultaneously obtain information on individual workers' and firms' characteristics. Fortunately, however, we could now match two data sources, the "Wage Structure Basic Survey" and the "Employment Administration Survey for Female Workers", but only in 2000. The former data contains information on individual employees' characteristics such as age, tenure, sex, schooling and wages, and the latter on firms' characteristics such as employee size, the numbers of female workers and managerial, and unionization. It is unfortunate that information on sales, profits and productivity were not collected in the Administration Survey[2].

[1] There is another line of research, which focuses on the impact of technological change on the wage structure. As surveyed briefly by Bartel and Sicherman(1999), these studies found a positive correlation between industry wages and technological change, using industry-level measures of technological change such as the capital to labor ratio, the industry's use of patents and productivity growth. Interestingly, Bartel and Sicherman argue that the wage premium associated with technological change is primarily due to the sorting of more able workers into industries with higher rates of technological change.

[2] In Japan Mitani(1997) also used the same kind of matched data as ours, focusing on the effect of firms' employment administration for female employees on wage differentials, but only for Osaka Prefecture.

Merging two data sources reduced the sample size. Originally, the sample size of the Wage Survey is about 0.5 million individual workers employed in about 50 thousand establishments. In turn, the Administration Survey contains about 7,000 samples of establishments. Since each of the surveys does not target to collect information on the same establishments, merging two sources reduces our sample size to about 30,000 workers in 800 establishments, which are managed by different firms.

The definitions and the basic statistics of the variables used in our analysis are shown in Table 1. The natural logarithm of the hourly earnings of a worker is defined as ln_wage, which is calculated as annual earnings including bonuses divided by annual hours worked. The annual earnings include overtime payments, but excludes various types of allowances such as alimony and commutation.

The variables listed from *exp* to *female* which are obtained from the Wage Survey, represent worker characteristics, and those from *per_uni* to *union* from the Administration Survey” do establishment attributes. The key variable, *exp_hat*, which is regarded as showing the firm’s wage policy, is defined as the marginal effect of experience in the wage equation, which is estimated for each establishment in the following form.

(1) $$\ln(wage) = \alpha + \beta_1 \exp + \beta_2 \exp^2 + \beta_3 uni + \beta_4 female + u ,$$

where *exp* stands for the labor market experience of workers, *uni* for the dummy variable of university graduator, *female* for the dummy of *sex* and *u* for the random term. By differentiating the right-hand side in the estimated equation with *exp*, we obtain $\beta_1 + 2\beta_2 \exp$. Substituting *exp* with 20 years, which is about the average labor market experience of workers in our sample, we get the slope of the wage profile, that is, *exp_hat*[3].

4 Empirical Results

4–1 Industry vs. Firm Size

[3] We also calculated *exp-hat* by substituting *exp* with the average labor market experience of workers for individual establishments, and used them for the analysis. The results are basically the same as those obtained by using *exp-hat* in the text.

To begin with, we estimate the basic equation in which the explanatory variables are only worker characteristics, that is, sex, experience, tenure and education[4]. As shown in equation 1 of Table 2, the effects of all these variables which have expected signs are statistically significant at the 1% level of confidence. As shown below, it should be stressed here that the coefficients of them are stable, regardless of the various ways of inclusions of the other variables. These results are consistent with those of the previous studies in Japan[5].

More precisely, first, it can be found from equation 1 to 4 in Table 2 that wages for female are about 17% lower more than those for male. Second, both the parameters on experience and tenure are positive, and the parameters of square terms are negative, as expected. It is interesting to note here that the negative coefficient of ***exp2*** is smaller than that of ***tenure2*** although the positive coefficient of ***exp*** is larger than that of ***tenure***. This suggests that wages are growing with experience and tenure, but tenure exerts stronger influence on wages than experience as workers become elder and have longer tenure. This has been regarded as one of the striking features of the Japanese labor market[6]. Lastly, education contributes to higher wages. Wages for university graduates are about 33% higher more than those for senior high-school graduates, and junior-college graduate are about 17% higher. In turn, wages for junior high-school graduates are 12.1% lower than those for senior-high school graduates.

Table 2 also shows the estimated equations including industry dummies and firm size (the logarithm of firm size) as explanatory variables. We find in equation 2 that the industry dummies, whose basis is textile industry, are significant at the 1% level of confidence except in the industry of fabricated metal products whose coefficient is nearly zero, and in equation 3 that the effect of firm size is also statistically significant. Note here that the inclusion of industry dummies to the basic equation increases the adjusted

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[4]As for the education dummies, senior high school graduate is the reference.

[5] See Genda(1998), Tachibanaki(1996) and Tachibanaki and Ohta(1994), for example.

[6] See Hashimoto and Raisian(1985) for this aspect.

$\overline{R}^2$ by 0.042 and that of firm size only by 0.002. Thus, judging from the adjusted $\overline{R}^2$, the explanatory power of industry is much larger than that of firm size.

The difference in the explanatory power between industry and firm size does not mean decisively that the wage differentials produced by firm size are smaller than those by industry. According to equation 4 in Table 2, where worker characteristic, industry dummies and firm size are used as explanatory variables, the highest wage differential among industries is 0.495 in proportion, of which value can be obtained by calculating the gap between the highest coefficient of electricity industry, 0.414, and the lowest of transportation and communication, -0.081. It is interesting to know to what extent firm size should differ in order to make up this highest differential among industries. Taking into consideration that the coefficient of firm size is 0.044 in equation 4[7], we find that the logarithm of the number of employees to make up for the largest industry differential in proportion is 11.25(=0.495/0.044), that is, the difference in firm size must be more than 73,000 employees. There is not such a big firm in our sample.

The above discussion comparing the maximum wage differentials between industries and firm sizes is only an example and not so meaningful. Rather it is important to compare the wage distribution due to different industries and that due to different firm sizes, controlling for the effects of the other variables on wage differentials.

Table 4 describes the coefficient of variation (C.V.) of estimated wage differentials weighted by the number of workers in industries or firm sizes. More specifically, the C.V. of the wage differentials due to different firm sizes is calculated as follows. First, we calculate the predicted values of wages for firm j whose size is L_j, from the estimated equation transformed in the following

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[7] Manning(2003) estimated the elasticity of wage with respect to employment to be in the region of 0.04, the estimate of which is similar to ours.

way.

$$(2) \qquad \hat{w}_j = \exp(\hat{\delta} L_j)\exp(\sum_{k=1}^{m} \hat{\beta}_k O_k + \sum_{i=1}^{n} \hat{\gamma}_i X_i),$$

where $\hat{\delta}$ is the estimated coefficient of firm size, $\hat{\gamma}_i$ is that of industry dummy X_i, and $\hat{\beta}_k$ is that of the other explanatory variable, O_k, such as experience. Note here that the standard deviations of the estimated wage distributions, which are also shown in Table 4, are dependent on the value of the second exponential in the right hand side of equation (2), but the coefficient variations are not[8]. That is, the C.V. is dependent only on $\hat{\delta}$ and L_j. Similarly, we can also calculate the C.V. of industry. Thus the indexes of Table 4 show the "pure" size of the wage distribution caused by different industries or firm sizes.

According to Table 4, wage differentials by industry effects are larger than those by firm size. For instance, see the result of the simulation based on the estimated equation including personnel characteristics, industry and firm size as explanatory variables. The C.V. of industry is 0.101, which is more than two times larger than that of firm size, 0.037. Table 4 shows that this tendency holds even if firm characteristics are added to the explanatory variables. Thus, as far as our data concerns, industry wage differentials are larger than firm size ones.

Note here that our data consists only of employees who work in large firms employing 100 and more regular workers. Therefore, it is quite possible that firm size wage differentials estimated above are biased downward. However, our main target is not to strictly compare wage differentials caused by industry and those by firm size, but to know how the introduction of firm characteristics will reduce estimated wage differentials and hence which is more closely related to efficiency wage aspects.

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[8] Krueger and Summers (1988) calculated the standard deviation concerning the effect of industry, adjusting for the standard errors of the industry coefficients.

4-2 Effects of Firm Characteristics

From our matched data we can obtain information on characteristics of firms and establishments where workers are employed, as listed in Table 1. Among them the most important variable for our analysis is the slope of wage profile of the firm, that is, *exp_hat*. This is because it can be considered to represent efficiency wage aspects more directly than industry and firm size. That is, firms make wage profiles steeper to deter worker shirking, to suppress quitting or to hire high-quality workers[9]. This policy, however, is not costless for two reasons[10]. One is that when capital markets are imperfect, steeper wage profiles force workers to consume less in the early period, leading to reduce their discounted utility over the lifetime. To cover this reduction firms must pay more. The other is that the steeper wage profile is risky for a worker because the firm may take the bond and fire the worker, claiming that he has shirked or because the worker has to quit the firm for the other reasons beyond his control such as ill health. This risk requires firms to pay higher wages to the worker. It is assumed here that as the wage profile becomes more steeped, the firm has to pay higher wages.

Equation 5 in Table 4 shows that the slope of wage profile of the firm has a positive effect on wages, as expected, and is statistically significant at the 1% level of confidence. It is interesting that the explanatory power is higher than that of firm size but smaller than industry. That is, the adjusted R squared, $\overline{R}^2$, in equation 5 with *exp_hat* included as explanatory variables is 0.645, which is between the $\overline{R}^2$ of equation 3 with firm size, 0.637,

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[9] There is another reason why firms offer steeper wage profiles. According to Mincer and Higuchi(1988), rapid technical changes and productivity growth need greater human investments in workers on the job, making wage profiles steeper. This problem will be discussed in Section 5.

[10] See Lazear(1981) and Carmichael(1985) for this topic.

and that of equation 2 with industry dummies, 0.677.

Firm characteristics other than ***exp_hat*** also play an important role in explaining wage differentials. Equation 7 shows that, except for increases in part-time workers(***inc_p***) and ratio of chiefs in establishment, they are statistically significant at the 10% level of confidence. Furthermore, by comparing equation 6 and 7 we know that the inclusion of the other firm characteristics raises the adjusted R squared by 0.009.

From equation 7 we can point out some interesting results in the following way. First, the result that the higher proportion of university graduates raises wages seems to support the efficiency wage hypothesis and the O-ring theory. In line with Akerlof(1982) it can be considered that when there are many university graduates who are generally high-wage workers, firms pay higher wages even to low-wage workers because of sociological reasons or that in the adverse case firms suppress wages to high-wage workers. The O-ring theory proposed by Kremer(1993) claims that, since many production processes consist of a series of tasks, any of which dramatically affects the product's value, firms attempt to hire high-quality workers in any job, leading to a positive correlation among the wages in different occupations within an establishment. The negative effect of the proportion of part-time workers(***per_part***) on wages can be explained similarly.

Second, interestingly the effect of the proportion of department managers(***per_gem***) is negative and statistically significant at the 5% level of confidence. Our interpretation is that since promotion to a general manager has many kinds of important values for employees, firms providing many posts of general managers might be able to get down wages without depressing employees' incentives. In turn, the proportion of section chiefs(***per_chief***) has a positive and statistically significant effect on wages. This holds even if ***per_gem*** is excluded from the estimation. Thus ***per_chief*** seems not to be effective for elevating employees' incentives. This is because most of university graduates can become section chiefs in general. But it is hard to explain why the effect of ***per_chief*** is positive[11].

[11] From interviewing a personnel staff, one of the authors got a hint

Third, employment growth has an important effect on wage differentials. Equation 7 shows that the dummy variable showing the employment growth of regular workers in the past 3 years(*inc_r*) has a positive and statistically significant effect on wages. In turn, the dummy showing the reduced number of regular workers(dec_r) has a negative and statistically significant effect. These results appear to support the recruiting models developed by Montgomery(1991) and Lang(1991).

Finally, unionism has a positive and significant effect on wages although its effect on wages for male workers and that for female differ greatly. That is, the marginal effect of the former is 5.8%, and that of the latter is 3.9%, which is obtained by reducing the effect of the interaction term (*union_f*). Interestingly this implies that unionism enlarges wage disparity between sexes because the difference in the average wage between both sexes is 17.9%, as known from the coefficient of female dummy in equation 7. These effects of unions are different from those obtained by Tachibanaki and Noda(2000) and Tsuru(2002). Their studies generally showed that the effect of unions on wages is not statistically significant at the ordinary level of significance after controlling for firm-size. Furthermore, Tachibanaki and Noda found even that the effect of unions on female employees can be positive.

The differences in the results among our analysis and those referred above are due to the data sources. Tachibanaki and Noda used model wage figures which unions use to compare wages of workers with the same age and tenure among different firms. Tsuru interviewed each employee to collect information for a questionnaire in Tokyo area. As pointed out by Tachibanaki and Noda, the use of the *Wage Structure Survey* published by the Ministry of Labor is desirable because its number of observations is large and because several important variables on individual workers are available. Unfortunately, however, it does not contain information on unionization. Our matched

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for an explanation. According to the staff, the span of control of section chiefs is recently narrowing because computerization makes the role of section chiefs more important in processing much information, and hence the ratio of section chiefs increases in some companies. In turn, the establishments which are highly computerized are productive and pay higher wages. However, this explanation is still tentative.

data now made it possible to link information on wages and individual workers' qualifications with the union status of each worker.

Our main concern is to analyze the effects of efficiency wage aspects on wage differentials by looking at how the inclusion of the slope of wage profile changes the estimated coefficients of industry dummies and firm size and the $\bar{R}^2$s. According to the comparison between equation 4 in Table 2 and equation 6 in Table 3, the values of the coefficients of industry dummies drastically change although they all keep statistical significance at the 5% level of confidence. In particular, the coefficients of all the industry dummies were decreased by the inclusion of *exp_hat*[12]. The industries whose coefficients were decreased in a great extent, that is, by more than 0.04, are mining, machine, electricity and trade.

Comparing equation 4 and 7, we know that the inclusion of other firm characteristics in addition to *exp_hat* also drastically changes the coefficients of the industry dummies. The coefficients of mining, construction, electricity, trade and finance industries, where higher wages are paid except in trade industry, were reduced by more than 0.05. It is also interesting that in the industries such as food, nonferrous metals, fabricated metal products and transportation, where wages are relatively low, the coefficients were decreased, but in a small scale. Thus we can say that the inclusion of firm characteristics affects the industry effects so as to reduce the wage differentials among different industries. Table 4 shows that the C.V. of wage distribution due to different industries was decreased from 0.101 to 0.094 by 0.007 after firm characteristics were controlled in addition to firm size and personnel characteristics.

The effects of firm size are affected in the same way as industry effects. Comparing equations 4 and 7, we can know that the coefficient of firm size was decreased from 0.044 to 0.042 by 0.002 due to the inclusion of firm characteristics. As a result of this decreases in

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[12]Note here that Textile industry is chosen as the reference of the other industry dummies because there are a large number of workers employed in textile industry and because lower wages are paid.

the firm size coefficient, the wage distribution caused by different firm sizes was reduced from 0.037 to 0.036 by 0.001. This reduced amount of C.V. is smaller than that of industry, 0.007. That is, it is quite possible that industry effects represent efficiency wage aspects more than firm size ones.

2-3 Alternative Approach

In this section, from another point of view, we will see the estimated results. As shown in Table 2 and 3, when personal and firm characteristics are added as explanatory variables, the coefficients of industry dummies and firm size became smaller. In order to analyze how the inclusion of these variables affects the estimated coefficients of industries and firm size, we calculate the biases caused by the omissions of worker and firm characteristics using equation 7. More specifically, let us define $\beta_{1,i}$ as the coefficient of the dummy of industry i estimated without worker and firm characteristics as explanatory variables, $\beta_{2,i}$ as that with them and $\beta_{2,k}$.as the estimated coefficient of the other variable k. Then $\beta_{2,I}-\beta_{1,i}$ is equal to $\Sigma\gamma_{ki} * \beta_{2,ki}$, where γ_{ki} is the estimated coefficient of industry dummy i obtained by regressing each of the other variables such as firm characteristics on industry dummies[13].

Table 5 gives the values of the omitted biases, $\Sigma\gamma_{ki} * \beta_{3,ki}$, and the contribution ratio of each of the omitted variables. According to this table, the average bias of industry dummies, which is weighted by the number of employees, is 0.230 and its 85% is caused by the omission of worker characteristics such as ***tenure*** and ***experience***. It is interesting that the bias caused by the omission of wage profiles is larger than that caused by the other firm characteristics. In turn, the bias of firm size is mainly due to the omissions of ***tenure*** and ***school***, and the other firm characteristics are relatively contributive to the bias.

These results suggest that the industry wage differentials seemingly observed reflect mainly differences in worker characteristics among industries and somewhat those in the wage strategy of firms. As for the seeming wage differentials among firms

13 See Greene(2003, chapter 8), for example.

of different size are due to differences in education, tenure and the firm characteristics other than wage profiles.

5. Some Problems

Using the slope of wage profile to estimate a wage function might be exposed to two criticisms. One is that the slope of wage profile, which is implied by efficiency wage models, is not effective for analyzing wage levels because it is suffering from the bonding critique. The other is that since firms simultaneously determine slopes of wage profiles and wage levels, the former must be endogenous in the analysis. We will deal with these problems in this section.

Against efficiency wage models there is a criticism that since firms are assumed to determine efficiency wages without regard to labor market conditions, many workers would apply to firms paying high wages. That is, critics of efficiency wages argue that job searchers who want a job in high-wage industries should propose to accept a lower wage in the form that they post a bond at the time of hiring. If firms caught the workers shirking or being unqualified, the firm could dismiss the worker and forfeit the bond. If it is not the case, the firm returns it to the worker at the time of retirement.

According to Carmichael(1990), firms can use many types of devices such as tournaments, promotions and upward-sloping age-wage profiles to have the worker pay the bond or the entrance fee. These devices make it possible for the firm to pay lower than the market wage to the new worker in response to labor market conditions. This leads to the conjecture that the steeper the age-wage profile of the firm the lower the wage in the early period of employment. This section will test this conjecture.

Panel A in Table 6 shows the estimated wage equations including the interaction terms of *exp_hat* and age groups[14] as explanatory variables. Note here that the interaction terms for the age group with ages 24 and less and that with ages 25-29 are negative and statistically significant at the 10% level. However, the coefficient of *exp_hat* which is significant at the 5%level of confidence is large, i.e., 0.657 while the interaction terms for workers with ages 24 and

[14] The reference is the group with ages 30-34.

less and those with ages 25-29 are small, i.e., −0.517 for the former and −0.507 for the latter. In addition, each of the estimated standard errors of both the interaction terms is small. These assure that, when the data separated by age group is used for the estimations, ***exp_hat*** has a significant effect for all age groups, as shown in Panel B of Table 6. But the effect of ***exp_hat*** for workers with ages 25-29 is not significant at the 10% level of confidence while those for the other age groups are. Therefore, it is possible that the ***exp_hat*** for the age group with ages 25-29 are less than zero, but its probability is quite small. Thus we can conclude that even young workers who work at firms where wage profiles are steeply rising are not paid lower.

How can we interpret that steep wage profiles have positive effects on wage levels in general? The most standard explanation is provided by human capital theory, as follows. Young workers start their work life at different levels of productivity depending on their innate ability and education, and accumulate human capital through on-the job training in firms where they are employed. Since in the process of training some workers learn more and some less, their wage profiles come to differ. Two problems, however, remain in this explanation. One is to explain the reason why workers learn more in some firms and less in others even if their levels of education and ages are the same. The other is related to competition implied by the bonding critique. If there is a firm that supplies much investment in OJT to its employees, many workers apply for it and hence the initial wages should decrease.

To solve the first problem, firm characteristics such as technical change must be introduced. As shown by Mincer and Higuchi(1988), larger investments in workers on the job were increased in industries which experience more rapid technical change and productivity growth in Japan. Greater demand for training is also explained by firm size, as discussed in Section 2. In addition, workers are innately heterogeneous in learning ability that is a crucial determinant of productivity over the life cycle. More specifically, in order to make OJT training more efficient it is important for firms to hire workers with high ability. However, firms cannot sufficiently observe workers' ability at the time of hiring and at least in the early stages of employment. Education provides only imperfect information about ability, and hence firms use several sorting devices such as interview and the brand of school name. Thus workers with high ability will be employed in firms where better training programs are provided and wage profiles are steeply upward although there can be existent some workers with low ability due to wrong sorting. The important thing is that efficiency wages work to allure for high quality workers, as implied by Weiss and Landau(1984).

Critics of efficiency wages may argue that young workers pay an entrance fee in the form that they receive wages which are lower than their labor productivity. The effectiveness of this discussion depends on tow assumptions. One is that young workers with high quality can be more productive even if their human capital investment is more than that of workers with low quality in the earlier stage of employment. The other is that labor productivity is firmly captured at the time of hiring so that the entrance fee to pay can be determined in the labor market. These two assumptions seem to be demanding in reality.

Farber and Gibbons (1996) developed the learning model to disentangle two basic findings. One is that the estimated effect of schooling on the wage differentials is independent of a worker's labor market experience against the expectation that the role of schooling in the inference process on his/her ability declines as performance observations accumulate in the labor market. The other is that time-invariant variables correlated with innate ability but unobserved by employers are increasingly correlated with wages as experience increases. They argue that if education is correlated with innate ability, two findings cannot be explained consistently by human capital considerations. To defend the attempt in this paper we consider that firms mainly use education to sort workers among occupations, such as production work and managerial, and that they determine whether to hire them for an vacant occupation, based on the other more effective signals such as certain test scores and the results of interview. Therefore, if occupational variables such as industry are controlled, as done in this paper, the problem pointed out by Gibbons and Farber can be mitigated in some extent.

Next, we will deal with endogeneity. The results obtained in the former sections imply that firms tend to pay higher wages in the later periods of employment, thereby resulting in steeper wage profiles. Therefore our assumption that the slope of the wage profile is an explanatory variable might be criticized from the ground that steeper wage profiles are the results of higher wages and hence must be endogenous.

To reply to the above criticism, we first note that steeper wage profiles require firms to pay higher wages basically for three reasons. The first is that greater human investments in workers and steeper wage profiles show the larger demand for high-quality workers, as discussed above. The second is that when capital markets are imperfect, steeper wage profiles force workers to consume less in the early period, leading to reduce the discounted utility over the lifetime, and hence firms are required to pay more. The third is that the steeper wage profile is risky for a worker because the firm may take the bond, claiming that the worker has shirked. Therefore, the worker demands higher wages over the lifetime.

The first reason among the three implies that technical change is a determinant of the slope of wage profile. Therefore, if technical change is exogenous to the firm's decision on the wage policy, then so is the slope of wage profile. As for the second and the third reasons, it can be considered that since the structure of wage profile is determined based on the long-term contract between the firm and the worker, the firm cannot flexibly change it in response to fluctuations in the short-term conditions such as profitability. Furthermore, in order to change the wage profile keeping the total cost of wages constant, the firm has to cut down some employees' wages. It is, however, difficult for the firm to accomplish this policy in the shot-run. That is, usually it takes much time to change the wage profile since the firm changes it using the average wage increment determined every year in the Spring Wage Offensive (*Shunto*). To sum up, our assumption that the slope of wage profile is exogenous is not so inappropriate in our cross-sectional analysis.

6 Conclusions

This paper attempted to empirically analyze the effects of inter-industry and firm size on wage differentials, focusing on how their estimated effects vary by the introduction of elements indicating wage policies of firms such as wage-experience profiles. Using the worker-establishment matched data, we found that inter-industry effects are larger than firm size, judging from their explanatory powers on wage differentials and the wage distributions caused by them, although the introduction of firm characteristics into the estimations reduces more the effect of the former.

Firm characteristics can be considered to represent efficiency wage aspects more directly than industry and firm size. Here it is interesting to know that the effects of industry and firm size still remain even after controlling for firm characteristics. This implies that industry and firm size include not only efficiency wage aspects but the other factors such as the monopoly power in the product market and technology, which are not controlled in this paper.

This paper also insisted that slopes of wage profiles have an effect on wage differentials on the basis of the efficiency wage hypothesis. However, the hypothesis is suffering from the bonding critique, which argues that job searchers who want a job in high-wage industries should propose to accept a lower wage by posting a bond at the time of hiring. This paper tested for the bonding critique by checking how steeper wage profiles affect wages of young workers. The result is that even those who work at firms where wage profiles are steeply rising are not paid lower. This result supports the efficiency wage hypothesis to be a good explanation for wage differentials.

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Table 1 Basic Statistics

Variable	Definition	Mean	Std. Dev.
Characteristics of Worker			
female	Dummy for Female Workers	0.207	0.405
exp	Experience	19.469	11.599
exp2	Square of Experience	5.136	4.979
tenure	Tenure	16.903	11.377
tenure2	Square of Tenure	4.151	4.445
jh	Junior high graduate (1)	0.065	-
hs	Highschool (Reference Group)	0.481	-
jc	Junior College graduate (1)	0.127	-
uni	University/Grad school graduate (1)	0.327	-
Characteristics of Firm/Establishment			
per_uni	Ratio of University graduate to regular workers	0.304	0.237
per_part	Ratio of Part-timer to all workers	0.080	0.132
union_f	Female * Union dummy	0.169	0.375
per_fem	Ratio of Female regular workers	19.454	19.368
per_gm	Ratio of General Manager at establishment	3.350	3.958
per_chief	Ratio of Chief at relevant establishment	9.009	8.053
a_age_m	Average Age of Male regular worker	40.409	3.272
a_age_f	Average Age of Female regular worker	33.650	4.494
inc_r	Regular Worker increased (2)	0.191	-
dec_r	Regular Worker decreased (2)	0.689	-
inc_p	Part-timer increased (2)	0.423	-
dec_p	Part-timer decreased (2)	0.279	-
union	Union dummy	0.889	-
exp_hat	Slope of wage profiles in worker's establishment	0.029	0.011
Industry Dummy(3)			
mining	Mining	0.002	-
const	Construction	0.017	-
food	Food/Beverages, Tobacco and Feed	0.033	-
texti	Textile (Reference Group)	0.008	-
lumber	Lumber, Wood products, Furniture and Fixtures	0.004	-
pulp	Pulp, Paper and Paper Products	0.094	-
chemi	Chemical	0.145	-
ceramic	Ceramic, Stones, Clay Products	0.029	-
iron	Iron and Steel	0.038	-
nonfer	Nonferrous metal	0.040	-
fab_met	Fabricated metal Products	0.030	-
machine	General Machinery	0.030	-
ele_mach	Electrical Machinery	0.087	-
transp	Manufacture of Transportation equipment	0.108	-
precision	Manufacture of Precision Instruments	0.082	-
electricy	Electricity, Gas, Heat supply and Water	0.033	-
trans_com	Transport and Communications	0.006	-
trade	Wholesale and Retail Trade, Restaurant	0.032	-
finance	Finance and Insurance, Real Estate	0.036	-
service	Services	0.147	-
Size of Firm			
ln_size	Logarithm of Number of Employees at Firm	7.004	0.760
Number of Observations		29771	

Note(1) These are dummy variables on workers' education whose reference group is "High school
Note(2) These are dummy variables on employment growth whose reference group is "Not Changed".
Note(3) The reference group is "Textile".

Table2 Wage Equations

	Equation 1			Equation 2			Equation 3			Equation 4		
l_hwage3	Coef.	Std.Err.	P	Coef.	Std.Err.	P	Coef.	Std.Err.	P	Coef.	Std.Err.	P
female	-0.168	0.004	0.000	-0.179	0.004	0.000	-0.168	0.004	0.000	-0.180	0.004	0.000
exp	0.038	0.001	0.000	0.037	0.001	0.000	0.038	0.001	0.000	0.037	0.001	0.000
exp2	-0.064	0.002	0.000	-0.063	0.002	0.000	-0.064	0.002	0.000	-0.062	0.002	0.000
tenure	0.022	0.001	0.000	0.023	0.001	0.000	0.022	0.001	0.000	0.023	0.001	0.000
tenure2	-0.009	0.002	0.000	-0.013	0.002	0.000	-0.009	0.002	0.000	-0.013	0.002	0.000
jh	-0.140	0.007	0.000	-0.118	0.007	0.000	-0.143	0.007	0.000	-0.121	0.007	0.000
jc	0.212	0.005	0.000	0.170	0.005	0.000	0.212	0.005	0.000	0.169	0.005	0.000
uni	0.371	0.004	0.000	0.333	0.004	0.000	0.371	0.004	0.000	0.330	0.004	0.000
mining				0.360	0.032	0.000				0.402	0.032	0.000
const				0.220	0.017	0.000				0.224	0.016	0.000
food				0.092	0.014	0.000				0.085	0.014	0.000
lumber				0.170	0.026	0.000				0.180	0.026	0.000
pulp				0.307	0.013	0.000				0.309	0.013	0.000
chemi				0.224	0.013	0.000				0.223	0.013	0.000
ceramic				0.116	0.015	0.000				0.106	0.015	0.000
iron				0.138	0.014	0.000				0.107	0.014	0.000
nonfer				0.094	0.013	0.000				0.083	0.013	0.000
fab_met				0.007	0.015	0.616				-0.013	0.015	0.367
machine				0.097	0.014	0.000				0.091	0.014	0.000
ele_mach				0.236	0.013	0.000				0.207	0.013	0.000
transp				0.156	0.013	0.000				0.121	0.013	0.000
precision				0.128	0.013	0.000				0.119	0.013	0.000
electricy				0.427	0.015	0.000				0.414	0.014	0.000
trans_com				-0.073	0.023	0.001				-0.081	0.023	0.000
trade				0.178	0.015	0.000				0.160	0.014	0.000
finance				0.354	0.014	0.000				0.360	0.014	0.000
service				0.274	0.012	0.000				0.261	0.012	0.000
ln_size							0.025	0.002	0.000	0.044	0.002	0.000
_cons	2.549	0.006	0.000	2.360	0.013	0.000	2.371	0.016	0.000	2.069	0.019	0.000
Nobs	29771			29771			29771			29771		
F-value	6475.530			2315.140			5802.260			2280.45		
Adj-R2	0.635			0.677			0.637			0.6819		

Table 3 Wage Equations

	Equation 5			Equation 6			Equation 7		
l_hwage3	Coef.	Std.Err.	P	Coef.	Std.Err.	P	Coef.	Std.Err.	P
female	-0.166	0.004	0.000	-0.178	0.004	0.000	-0.179	0.009	0.000
exp	0.037	0.001	0.000	0.037	0.001	0.000	0.037	0.001	0.000
exp2	-0.062	0.002	0.000	-0.061	0.002	0.000	-0.060	0.002	0.000
tenure	0.022	0.001	0.000	0.023	0.001	0.000	0.022	0.001	0.000
tenure2	-0.011	0.002	0.000	-0.014	0.002	0.000	-0.015	0.002	0.000
jh	-0.132	0.007	0.000	-0.116	0.007	0.000	-0.114	0.007	0.000
jc	0.207	0.005	0.000	0.168	0.005	0.000	0.154	0.005	0.000
uni	0.353	0.004	0.000	0.318	0.004	0.000	0.294	0.004	0.000
per_uni							0.093	0.009	0.000
per_part							-0.145	0.013	0.000
per_fem							0.001	0.000	0.000
per_gm							-0.002	0.000	0.000
per_chief							0.001	0.000	0.001
a_age_m							0.009	0.001	0.000
a_age_f							-0.002	0.000	0.000
inc_r							0.010	0.006	0.063
dec_r							-0.015	0.005	0.003
inc_p							0.001	0.004	0.850
dec_p							-0.010	0.004	0.010
union							0.058	0.006	0.000
union_f							-0.019	0.010	0.050
exp_hat	4.276	0.144	0.000	3.476	0.140	0.000	3.124	0.148	0.000
mining				0.350	0.032	0.000	0.286	0.032	0.000
const				0.187	0.016	0.000	0.159	0.017	0.000
food				0.057	0.014	0.000	0.072	0.014	0.000
lumber				0.160	0.026	0.000	0.227	0.026	0.000
pulp				0.282	0.013	0.000	0.286	0.013	0.000
chemi				0.196	0.013	0.000	0.192	0.013	0.000
ceramic				0.075	0.015	0.000	0.077	0.015	0.000
iron				0.096	0.014	0.000	0.088	0.015	0.000
nonfer				0.069	0.013	0.000	0.072	0.014	0.000
fab_met				-0.025	0.015	0.083	-0.029	0.015	0.053
machine				0.044	0.014	0.002	0.043	0.015	0.004
ele_mach				0.181	0.013	0.000	0.188	0.013	0.000
transp				0.100	0.013	0.000	0.105	0.013	0.000
precision				0.098	0.013	0.000	0.102	0.013	0.000
electricy				0.362	0.014	0.000	0.348	0.015	0.000
trans_com				-0.086	0.023	0.000	-0.112	0.023	0.000
trade				0.119	0.014	0.000	0.097	0.015	0.000
finance				0.336	0.014	0.000	0.310	0.015	0.000
service				0.233	0.012	0.000	0.236	0.012	0.000
ln_size				0.045	0.002	0.000	0.042	0.002	0.000
_cons	2.438	0.007	0.000	1.996	0.019	0.000	1.686	0.028	0.000
Nobs	29771			29771			29771		
F-value	6022.62			2268.91			1631.47		
Adj-R2	0.6454			0.6884			0.697		

Table 4 Coefficients of Variations and Standard Deviations of Industry and Firm Size Wage Distributions

Explanatory Variables (Used Estimated Equation)	Industry C.V.	Std.Dev.	Size C.V.	Std.Dev.
Woeker Characteristics+Indusries+Firm Size (Equation 4)	0.101	0.972	0.037	0.399
Worker Caracteristicse+Indusries+Firm Size+Firm Characteristics (Equation 7)	0.094	0.600	0.036	0.261

Table5 Effect of the Worker and Firm Characteristics on Industry/Size Coefficient

Share of Contributions(%

	Total Effect (Bias)	Worker characteristics female	experience	tenure	school	Wage Profile exp_hat	Other Firm Characteristi
Industry Total	0.230	21.644	21.925	31.028	10.174	11.479	3.751
ln_size	0.014	0.000	-4.253	39.123	46.570	-3.230	21.789

Table6 Wage Equations by age group

Panel A	Coef.	Std.Err.	P
exp_hat	0.657	0.181	0.000
exphat_age-24	-0.515	0.273	0.059
exphat_age25-29	-0.507	0.166	0.002
exphat_age35-39	1.482	0.177	0.000
exphat_age40-44	3.585	0.209	0.000
exphat_age45-49	6.025	0.241	0.000
exphat_age50-54	9.435	0.290	0.000
exphat_age55-	13.143	0.403	0.000
Nobs	29771		
F-value	1482.92		
Adj-R2	0.7092		

Panel B	Coef.	Std.Err.	P	Nobs	F-value	Adj-R2
- 24	0.969	0.383	0.011	1991	40.32	0.4535
25-29	0.280	0.282	0.321	4866	49.23	0.294
30-34	0.899	0.316	0.005	4657	68.58	0.3787
35-39	2.368	0.382	0.000	3928	67.4	0.4153
40-44	3.990	0.457	0.000	3233	80.45	0.508
45-49	6.690	0.473	0.000	3782	105.79	0.5379
50-54	8.899	0.501	0.000	4091	139.6	0.5873
55-59	14.160	0.739	0.000	2531	83.99	0.5794

Note1: Panel. A shows the result of the wage equation using all the cross-terms of exp_hat and age group. The reference group of the cross-terms is with age 30-34. The estimated results of the other explanatory varibales are ommitted.

Note2:Panel. B shows only the results on exp_hat obtained by estimations by a; group.