The Effects of the Unemployment Rate on the Wage Profile*

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Abstract

This paper addresses the phenomenon in Japan that the macro wage profile became flatter while its unemployment rate increased in the 1990s. It implies that the skill accumulations in Japanese economy got worse during the "lost decade," considering that the slope of the wage profile reflects workers' skills. In this paper, it is shown that the decrease in the slope was the result of the increase in the unemployment rate, based on the idea that it has the effect of preventing workers accumulating skills on the job. I use an OLG model incorporating a search model in which workers accumulate skills when employed and lose them when unemployed.

1 Introduction

In the 1990s, the macro wage profile has become flatter in Japan (See Table 1). The wage profile in Japan is sometimes discussed in the context of the "Japanese Employment System". For example, the flattered wage profile is referred as the result of that the seniority wage system came to be less prevailing in Japan. However, existence or peculiarity of the "Japanese Employment System" is still controversial. Koike (1978 and 1995) claims there are no evidence of "Japanese Employment System" or peculiarity in Japanese data. Hall (1982) investigated patterns of job duration by several categories and found the importance of the lifetime jobs in the U.S. Economy. Hashimoto and Raisian

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Table 1 The SLOPE and the Unemployment Rate (MALE)

	1990	2000
UNEMPLOYMENT RATE	2.04	4.89
SLOPE	7940.8	7291.8

Sources: 1. (Unemployment Rate) Ministry of Internal Affairs and Communications, Statistics Bureau,"Labor force Survey (Rodoryoku Chosa), 2003".
2. (Wage) Ministry of Health, Labour and Welfare, "The basic survey on wage structure(Chingin Kozo Kihon Tokei Chosa), 1990-2002".

(1985) claims that earnings-tenure profiles are more steeply sloped in Japan than in the United States. This paper offers an account of the flattered wage profile based on the skill accumulation on the job, without relying on any doubtful system or peculiarity in Japanese data.

The wage profile considered in this paper is defined as the plot of the average wage level by age group in a graph whose vertical axis is wage and whose horizontal axis is age. The slope of the wage profile is defined as follows.

$$SLOPE \equiv \frac{maxWAGE - startWAGE}{maxWAGEindex - 1} \tag{1}$$

where $startWAGE$ is the average wage level of the youngest age group, and $maxWAGEindex$ is the index of the age group whose average wage is highest, $maxWAGE$. For example, if the age-wage profileis "10, 20, 30, 40, 35, 32," then $startWAGE = 10$, $maxWAGE = 40$, $maxWAGEindex = 4$, and then $SLOPE = 10$. When comparing the values of several slopes using this definition, it is important to use the same $argmaxWAGE$ for all slopes compared. I calculated all slopes with the minimum $argmaxWAGE$ among the $argmaxWAGEs$ of all the wage profiles considered. These definitions are consistent for preceding literature, for example Mincer (1974), Hashimoto and Raisian (1985), Mincer and Higuchi (1988), and Koike(1995).

In the 1990s, the slope of the wage profile for male declined by 649 in real term based on the definition (1), while the unemployment rate (male) increased to about double, as shown in Table 1. [*1]

[*1] I used only male data because female one seems to have the selection bias. Many of female workers in Japan quit their job and become non-labor force around the age 30 and go back to labor force and work again around the age 40, while male labor force remains almost constant.

Table 2　The Covariance and the Correlation

CORR(UNEMP, SLOPE)	CORR(UNEMP, J-S RATIO)
-0.968	-0.792

Sources: 1. (Unemployment Rate) Ministry of Internal Affairs and Communications, Statistics Bureau "Labor force Survey (Rodoryoku Chosa), 2003." 2. (Wage) Ministry of Health, Labour and Welfare, "The basic survey on wage structure (Chingin Sensasu), 1990-2002." 3. (Job-offers-to-seekers Ratio) Ministry of Health, Labour and Welfare, Employment Security Bureau"Statistics of Employment Security (Shokugyo Antei Gyoumu Toukei), 1990-2000."
Notes: "UNEMP," "SLOPE," and "J-S RATIO" stand for the unemployment rate, the slope of the wage profile, and the job-offers-to-seekers ratio, respectively.

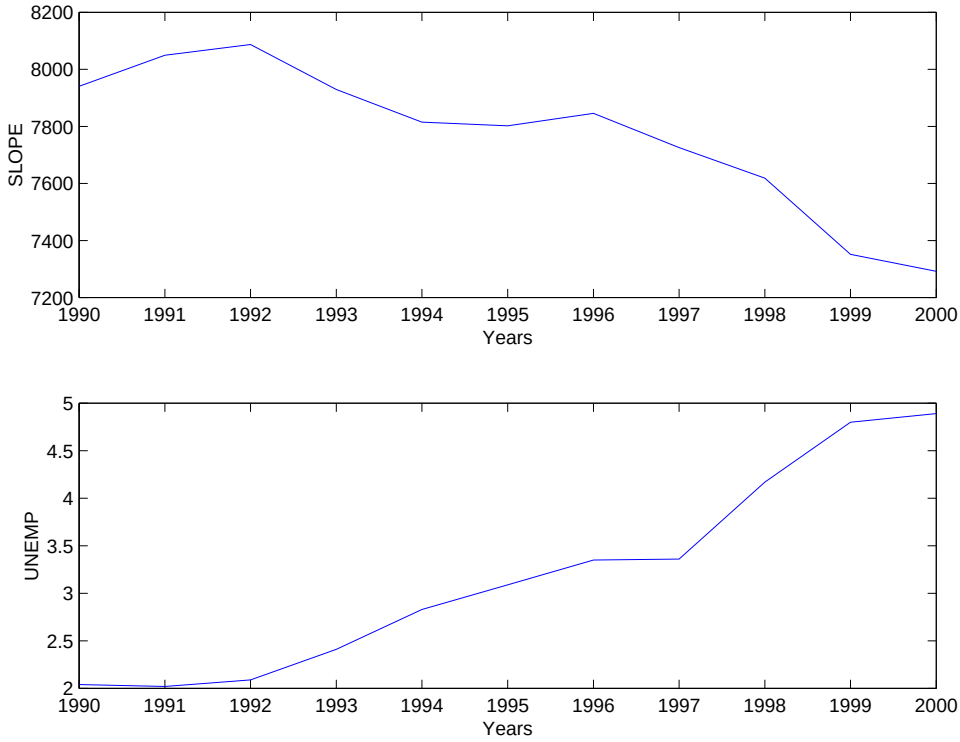

Figure 1　The SLOPE of the age-wage profileand Unemployement Rate (MALE)

Sources: 1. (Unemployment Rate) Ministry of Internal Affairs and Communications, Statistics Bureau "Labor force Survey (Rodoryoku Chosa), 2003".
2. (Wage) Ministry of Health, Labour and Welfare,"The basic survey on wage structure (Chingin Sensasu), 1990-2002".

I used the wage data of ten age groups, which is from ”Statistical Survey of Wage Structure(Chingin Kozo Kihon Tokei Chosa), 1990-2000”. The first age group is 15-19 and the last one is 60-65, where each age group include five ages. Since the reported wage data is nominal, I transformed it into real term in dividing it by a price index which is taken from “the consumer price index.” [*2] The unemployment rates are from ”Labor Force Survey (Rodoryoku Chosa), 1990-2000.”

The negative relationship between the unemployment rate and the slope of the wage profile was not a special event which happened only between 1990 and 2000. As shown in Table 2, the slope of the wage profile was highly negatively correlated with the unemployment rate in the 1990s; the correlation coefficient was -0.97. They are plotted in Figure 3. The unemployment rate is also closely related to the job-offers-to-seekers ratio which indicates how many vacancies exist per unemployed people.[*3] The job-offers-to-seekers ratio, whose values in the 1990s are shown in Table 3, was positively related to the unemployment rate (Table 2).

The human capital theory, one of the most popular works on which is Becker (1993), claims that wages rise with seniority because job tenure is correlated with acquisitions of skills. Namely, the increase in the wage is seen as the improved labor productivity, in other words, the skill accumulation. Considering the job and firm specific skills, it is reasonable to imagine that workers lose some skills when separated. During unemployment, people lose their skills because they usually have no chance to use or update them, in addition to the lack of job training. These claims are supported by some empirical works. [*4]

According to the theory, the steepness of the macro wage profile, which is the plot of the average wage levels by age or age group, is also accounted for by the skill accumulation on the job. Becker (1993) and Mincer (1974) attribute the steepness of the wage profile to the amount of the human capital investment. They claim that the more job training implies the steeper wage profile. The proposition was supported by several

[*2] It is the 2000-base CPI provided by Ministory of Internal Affairs and Communications, Statistics Bureau.

[*3] The ratio of job offers to job seekers is the ratio of officially registered job openings against officially registered job applications. This statistics is provided by Ministry of Health, Labor and Welfare, Employment Security Bureau.

[*4] Mincer (1974) provides empirical studies of earning profiles and human capital acquisitions. Jacobson et.al.(1993) reported that displaced workers suffer substantial earning losses using a Pennsylvania data. Mincer and Higuchi (1988) referred that skills became obsolete if they are rapidly modified in the market place when technology changes rapidly, even without “forgetting,” and reported the obsolescence effects on wages for Japan.

Table 3 The Job-Offers-to-Seekers Ratio

year	1990	1991	1992	1993	1994	1995
job-offers-to-seekers ratio	1.4	1.4	1.08	0.76	0.64	0.63
year	1996	1997	1998	1999	2000	
job-offers-to-seekers ratio	0.7	0.72	0.53	0.48	0.59	

Source: (Job-offers-to-seekers Ratio) Ministry of Health, Labour and Welfare, Employment Security Bureau"Statistics of Employment Security (Shokugyo Antei Gyoumu Toukei), 1990-2000."

empirical works, for example, Hashimoto and Raisian (1985) and Mincer and Higuchi (1988).

In this paper, instead, I claim the proposition that the higher the unemployment rate is, the flatter the macro wage profile is. Even if the amount of the human capital investment is unchanged, the increase in the number of the unemployed deteriorates the human capital accumulation. Given certain rates of skill accumulation and deterioration, an average skill level in an age group gets lower when workers who have experienced unemployment increase. Since this effect, of course, gets larger in older age groups, the slope of the macro wage profile[*5] gets smaller when the unemployment rate increased.

The human capital accumulation on the job and the loss of skills has been considered to investigate persistence in unemployment, too. Pissarides (1992) explains that an increase in the unemployment rate leads the decrease in the level of human capital and then suggested the " thin market mechanism" as a mechanism of the serially correlated deviations of real economic aggregates from trends. The persistent deviations are also investigated by Ljungqvist and Sargent (1998) and Esteban-Pretel (2003) considering skill accumulation. Fukuda and Owen (2004) argues firm-specific human capital investment and explains persistent negative effects on macro performances of a transient decrease in TFP. These papers suggest that the average skill level in the whole economy decreases when the unemployment rate increases, although they do not mention to the wage profile steepness implicitly.

This paper provides a model to investigate the wage profile explicitly in the context of the human capital accumulation on the job. The skill considered in this model can be understood as the composition of the general skill and the job specific one. It is shown that the recent Japanese phenomenon can be explained by the mechanism that an

[*5] I will refer to the macro wage profile as just wage profile. Since I will not deal with personal wage profiles in this paper, there will be no confusion.

increase in the unemployment rate make the wage profile flatter.

The rest of this paper consists of five sections. In section 2 and 3, I provide a model to investigate the wage profile directly and examine it by numerical simulations. Then, I report the calibration of the model and the comparative static analysis in section 4 and 5. The concluding remarks are in section 6.

2 MODEL

2.1 ENVIRONMENT

I employ an N-periods OLG model incorporating a search model in which workers accumulate skills when employed and lose them when unemployed. There is a continuum of workers which is measure one in each cohort and each worker is born unemployed. A worker's preference is assumed to be

$$E_t \sum_{j=0}^{N-1} \beta^j y_{t+j} \tag{2}$$

where $\beta \in (0,1)$ is the worker's discount factor, y_{t+j} is income in period $t+j$, and E_t is the expectation conditional on the date t information. In this model, it is assumed that the time t utility function $u(y_{t+j})$ is equal to y_{t+j}. This assumption means that workers are risk neutral and thus they are not interested in consumption smoothing.

In each period, with probability μ, an unemployed worker gets an offer w from the wage distribution $F(W) = Prob\{w \leq W\}$, whose support is $[\underline{w}, \bar{w}] \in R^2_{++}$. The arrival rate of an offer $\mu \in (0,1)$, which is given exogenously in this model, can be understood as a friction in the labor market, or as a indicator of the condition of the labor demand side. Employed workers faces a separation rate $\lambda \in (0,1)$, which is given exogenously in this model. There are no quits in this model.

All workers experience stochastic transition of skills; an employed worker is likely to accumulate skills while an unemployed worker is likely to deteriorate them. The skill level $\{h_t\}$ is the markov chain with the finite state space $h = [h_1, \cdots, h_n]$, the initial distribution $\bar{h} = [1, 0, \cdots, 0]'$, and the 3 types of (n×n) transition matrices $\Phi_i (i = E, SP, U)$ which is respectively for an employed, a just separated, and an unemployed worker. Therefore, an employed worker whose skill level is h improve his or her skill level to h' with a probability $\Phi_E(h, h')$ at the beginning of the next period, if he or she will not separated. If the worker is separated, his or her skill is deteriorated to h'' with a probability

$\Phi_{SP}(h, h')$. After this initial period of a layoff, the worker's skill level follows the transition probability $\Phi_U(h, h')$ until he gets employed. The initial distribution reflects that all workers are born with the lowest skill, this is because the skill is the one accumulated only on working.

The timing of the model economy is as follows. At the beginning of a period, the fraction λ of employed workers are separated and enter the unemployment pool. Then, all workers experience the skill transition based on their employment status; employed, separated, or continuously unemployed. After the skill transition, unemployed workers search their job and receive an offer with probability μ, and the offered workers decide whether they accept the offer or not. When the decisions are made, the unemployment rate and the wage profile in the period are determined.

2.2 The Probblem of Worker

The worker's problem is to maximize the expected value (2). Therefore, the worker's interest is to choose a policy function to decide whether or not to accept any particular job offer in any situation. With probability μ, unemployed workers draw one independent identically distributed offer from the known distribution F. The worker has the option of rejecting the offer, in which case he or she is unemployed in this period and waits until next chance, possibly in the next or further period, to draw another offer from F. If the worker accepts the offer to work at w, in which case he or she receives a wage of w per period until he or she gets separated. Therefore, the income y_{t+j} is assumed to be as follows;

$$y_{t+j} = \begin{cases} wh_{t+j} & \text{if employed at a wage } w \\ c(\geq 0) & \text{if unemployed} \end{cases} \tag{3}$$

where c is some real value, such as the pecuniary value of leisure and home production activities. The hours of working is fixed to unity and then w is the wage per unit of skill.

Let $V_E^j(w, h)$ and $V_U^j(h)$ denote the expected maximum value of which the age j worker whose skill level is h accepts an offer w, and that of which rejects it, respectively. Then, the Bellman's equations can be written as follows. For the final period,

$$V_E^N(w, h) = wh \tag{4}$$

$$V_U^N(h) = \mu E \max\{wh, c\} + (1 - \mu)c. \tag{5}$$

And for the age $j(\neq N)$,

$$V_E^j(w,h) = wh + \beta(1-\lambda)\sum_{h'}\Phi_E(h,h')V_E^{j+1}(w,h') + \beta\lambda\sum_{h'}\Phi_{SP}(h,h')V_U^{j+1}(h') \quad (6)$$

$$V_U^j(h) = \mu E\max\Big\{wh + \beta(1-\lambda)\sum_{h'}\Phi_E(h,h')V_E^j(w,h') + \beta\lambda\sum_{h'}\Phi_{SP}(h,h')V_U^{j+1}(h'), c + \beta\sum_{h'}\Phi_U(h,h')V_U^{j+1}(h')\Big\} + (1-\mu)\Big\{c + \beta\sum_{h'}\Phi_U(h,h')V_U^{j+1}(h')\Big\} \quad (7)$$

Then, the reservation wage for the age j worker R^j is the wage such that

$$R^j h = c, \quad \text{for } j = N \quad (8)$$

$$R^j h + \beta(1-\lambda)\sum_{h'}\Phi_E(h,h')V_E^j(R^j,h') = c + \beta\sum_{h'}\Phi_U(h,h')V_U^{j+1}(h') - \beta\lambda\sum_{h'}\Phi_{SP}(h,h')V_U^{j+1}(h'), \text{ for } j \leq N-1. \quad (9)$$

Since the left hand sides of the equation (8) and (9) are increasing in w and the right hand sides of them are independent of w, there exists an unique R^j for all j. The optimal policy is to accept any offer above the researvation wage.

2.3 Stationary Equilibrium

Here, I define a recursive stationary equilibrium for this economy as follows.

Definition Given an exogenous wage distribution $F(\cdot)$, separation rate λ, the arrival rate of an offer μ, and a markov chain $(\Phi_i(i = E, SP, U), \bar{h})$, a recursive stationary equilibrium consists of value functions $\{V_E^j(\cdot,\cdot), \{V_U^j(\cdot)\}_{j=1}^N$, policy functions $\{R^j(\cdot)\}_{j=1}^N$, and a time-invariant distributions of age "j" individuals $\Gamma(w,h,s,j)$ such that

1. The policy functions $\{R^j(h)\}_{j=1}^N$ solve the worker's maximization problem.
2. The statonary distribution
   $$\Gamma(w,h,s,j) = \Gamma^{CE}(h) + \Gamma^{JC}(h,w,j) + \Gamma^{JE}(h,w,j) + \Gamma^{CU}(h,j) + \Gamma^{JU}(h,j)$$
   is induced by $(\Phi_i(i = E, SP, U), \bar{h})$, the separation rate λ, the arrival rate of an offer μ, and $\{R^j(\cdot)\}_{j=1}^N$, where CE, JC, JE, JU, and CU stand for the states of continuously employed, job changed, just employed, just unemployed, and continuously unemployed, respectively.

Since this model has generations, there are two generational heterogeneous properties which do not exist in any infinite horizon search model. The first one is in the workers' decision: The policy function $R(h, j) \equiv R^j(h)$ is non-increasing function of the age j. Since the life is finite, the older the worker is, the lower the benefit to reject an offer w and wait for the next offer. For example, an unemployed worker in the last period, the benefit to wait is zero with probability one. Therefore, the worker directly compares the offered wage w and c. The second property is about the heterogeneity of the average skill levels in age groups. The average accumulated skill level in an age group is higher as the age is higher, because the number of higher skilled worker is greater. These are important factors in investigating the wage profiles, too.

The slope of the wage profile in this model is calculated based on the definition (1). The only point at which we have to be careful is the word "wage." In calculating the wage profile or its slope, we have to take average of $w \times h$ in each age group, but not solely w. This is because the total payment from firm is the $w \times h \times 1$. From this point, it is clear that the wage profile and its slope are determined by reservation wages and the average skill level in each age group.

3 Numerical Simulation

In this section, I will show how an increase in the unemployment rate decreases the slope of the macro wage profile, by simulating the model described in the previous section. I will report the simulated values of the slope of the wage profile for several values of the unemployment rate. Since the unemployment rate is endogenous in this model, it is not possible to set it to arbitral values directly. Instead, I change the value of μ, which is an exogenous variable, in order to adjust the value of the unemployment rate.

I set the number of periods to ten which is same as the data shown in the previous sector. One period in this model corresponds to five years since the labor force considered in this paper is from the age 15 to 65. The discount factor β is set to 0.7738, that is, the factor for one year is 0.95. I set λ to 0.22, which is the same value as in the application in the next section. The distribution of the wage offer w is assumed to be the uniform distribution which is defined on the interval [0, 1]. The value of unemployed, c, is set to zero.

Table 4 Numerical Simulation Results

UNEMP	10%	11%	12%	13%	14%	15%
Slope	0.289	0.281	0.275	0.271	0.266	0.26
μ	0.95	0.9	0.85	0.83	0.8	0.75
$ASKILL_{whole}$	3.73	3.66	3.59	3.56	3.53	3.45
$ASKILL_1$	1	1	1	1	1	1
$ASKILL_2$	1.61	1.61	1.61	1.61	1.61	1.61
$ASKILL_3$	2.29	2.28	2.26	2.26	2.25	2.23
$ASKILL_4$	2.95	2.92	2.89	2.88	2.86	2.83
$ASKILL_5$	3.59	3.54	3.49	3.47	3.44	3.38
$ASKILL_6$	4.18	4.11	4.04	4.01	3.97	3.89
$ASKILL_7$	4.73	4.63	4.54	4.5	4.45	4.35
$ASKILL_8$	5.22	5.11	4.99	4.94	4.88	4.76
$ASKILL_9$	5.67	5.53	5.38	5.32	5.25	5.09
$ASKILL_{10}$	6.06	5.9	5.72	5.66	5.57	5.39

I set five different skill levels whose values divide the interval $[1, 10]$ evenly. As I described in the previous section, all workers are born with the lowest skill level, and then the initial distribution is set to $\bar{h} = [1, 0, 0, 0, 0]'$. At the beginning of a period, workers who were employed in the previous period and who are not followed by a separation improve it by one level with probability 0.5, or keep their skill level unchanged with probability 0.5. If the worker has already obtained the highest level of the skill, he or she keeps it with probability one.

Whereas, workers lose their skills with some probability if they are just separated or unemployed. The just separated workers' skills are deteriorated by one level with probability 0.5, or kept unchanged with probability 0.5. Namely, the skill deterioration rate for just separated workers is assumed to be same as the rate of employed workers' skill accumulation. The workers who have been unemployed more than one period lose their skills severely, that is, the skill level falls to the lowest one with probability 0.9, and to the second lowest one with probability 0.1. Since one period corresponds to five years, the assumption that the worker loses almost all of the accumulated skills is reasonable.

The simulated results are shown in Table 4. I also put the values of μ in the table,

which is set to produce the appropriate unemployment rate.[*6] This simulation results show that the higher the unemployment rate is, the smaller the slope of the wage profile. This is caused by the deterioration of the accumulation of skills: the increase in the unemployment rate leads the smaller number of workers who can accumulate their skills in the whole economy. It involves the more losses of skills and thus the increase of the number of low skilled workers in each age group. Therefore, the slope of the wage profile gets lower.

This mechanism is understood from the simulated changes in the average skill levels of age groups and in the average skill level in the whole economy. The average skill levels in age groups show how the skills in the economy accumulated. You can see how the skill accumulation deteriorates as the unemployment rate increases in the simulated $\{ASKILL_j\}_{j=1}^{10}$ in Table 4. It is also clear that the average skill level in the economy $ASKILL_{whole}$ decreases as the unemployment rate increases. This result is consistent to preceding literature of human capital accumulation on the job.

The result that the higher unemployment rate is associated to the flatter wage profile can be obtained under almost all combinations of "appropriate" parameter values. "Appropriate" means that the parameters represents the assumptions well; for example, the values of Φ_E imply skill accumulation, not deterioration and the number of the periods is big enough to consider the dynamics of the skills. I found that simulation with a small number of periods, for instance two or three periods, does not always provide stable result.[*7] This implies that we have to think about the number of periods of the model carefully when we consider the skill accumulation.

4 Calibration

In this section, I will calibrate the model to the Japanese economy in 1990. As in the numerical simulation, I set the number of periods to 10, which is same as the number of age groups in the data. Therefore, one period corresponds to five years. The discount rate for one year is set to 0.95, thus the discount factor for one period in thie model is 0.7738 ($= 0.95^5$). I set λ in order that the model can produce the unemployment rates in

[*6] In this exercise, I do not care about the figures after the second dicimal fractions in the unemployment rate.

[*7] The proof of the result is highly complicated and the effect of the increase in μ on the reservation wage differs among age groups.

Table 5 Calibration

VARIABLE	VALUE
β	0.7738
λ	0.22
$mean\{w\}$	21922
$F(w)$, for $j \leq 7$	U(10961, 32883)
$F(w)$, for $j \geq 8$	U(10961, 11180)
c	5480.5
Number of Skill Levels	5
$min\{h\}$	1
$max\{h\}$	4.89134

the 1990s; the range of the unemployment rate varies according to λ.

The wage distribution is assumed to be a uniform distribution as in the previous section. In addition, I assumed that the distribution for the old worker is different from the younger workers considering the mandatory retirement system in Japan. The retirement age in Japan is distributed from about the age 55 to 65. Since the acquisition skills is time-consuming, firms do not think that a worker who is just ahead of the retirement age brings them as much benefits as a young worker does. There is not enough time for the old workers to acquire skills, especially firm-specific ones, and to contribute for firms. On the other hand, the old worker accepts almost all of the offers if the value of unemployment, c, is low enough, since the benefit of waiting for the next offer, which is possibly higher than the current offer, is trivial. Thus, it is reasonable to assume that the workers just ahead of the retirement age receives ”take-or-leave-it-offer”.

I set the mean of the wage offer for younger workers, $mean\{w\}$, to 21922, in order to equate the average value of the 15-19 age group in the model with that in 1990: 23140. Since the all workers are assumed to be born with the lowest skill, that is $h = 1$, the average wage in the first age group corresponds to the mean of the wage offer. The minimum and the maximum wage is a half of the mean wage $\bar{w}$ and the three seconds of it, respectively. Based on the ”take-or-leave-it-offer” assumption for old workers, I define the wage distribution for the old workers as the uniform distribution whose domain is lower one percent area of that of the younger workers' one. The value of c is set to a half of the minimum wage.

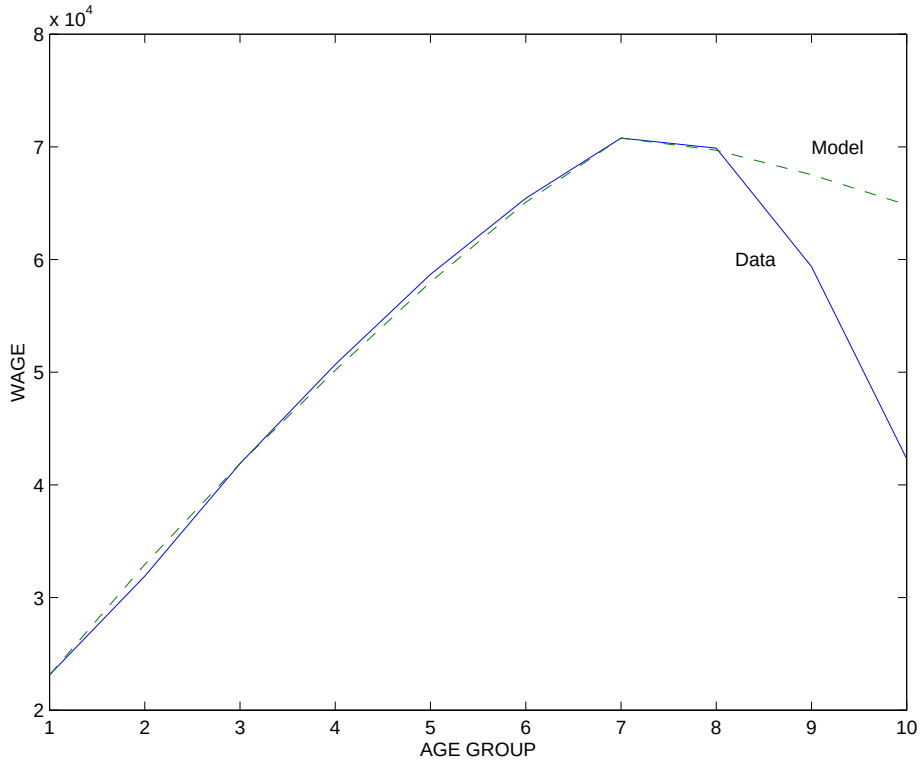

Figure 2 The Calibrated Wage Profile in Japan

NOTE: The solid line denoted by "Data" is the actual wage profile in 1990, while the dotted line denoted by "Model" is the calibrated wage profile.

I employ five different skill levels and posit that just separated workers lose their skills at the same probability that an employed worker can improve the skill level, as I explained in the previous section. Also, I assumed that the long-term unemployed workers lose almost all of their skills, that is,

$$\Phi_U = \begin{bmatrix} 1 & 0 & 0 & 0 & 0 \\ 0.9 & 0.1 & 0 & 0 & 0 \\ 0.9 & 0.1 & 0 & 0 & 0 \\ 0.9 & 0.1 & 0 & 0 & 0 \\ 0.9 & 0.1 & 0 & 0 & 0 \end{bmatrix}. \tag{10}$$

I calibrate the values of Φ_E and the maximum value of h in order to reproduce the wage profile in 1990, assuming the minimum value of h to be one. The procedure consists of three steps. First, I set the values of Φ_E to make the model wage profile capture the shape of the increasing part of the wage profile in 1990, given the assumption on Φ_{SP} and the values of Φ_U. Second, I divide the wage levels of all age groups in 1990 by the wage level of the first age group (15-19 age group) in 1990. And then calculate the slope in 1990 according to the definition (1). Finally, I adjust the maximum value of h in order

Table 6 The Model and The Data

	SLOPE (1990)	SLOPE(2000)	CORR(UNEMP,SLOPE)
DATA	7940.8	7.2918	-0.968
MODEL	7940.8	7650.2	-0.999

to reproduce the slope of the wage profile in 1990.

The values, which are finally determined in the procedure above, are as follows. $\Phi_E(j, j)$, $\Phi_E(j, j+1)$, and $\Phi_E(j, k)$ for $j = 1, \cdots, 4, k \neq j, j+1$ are determined to 0.6, 0.4, and 0, respectively. $\Phi_E(j, j)$ and $\Phi_E(j, k)$ for $j = 5, k \neq 5$ are set to 1 and 0. The determined maximum value of h is 4.8849. The rest of the values of h evenly partition the interval [1, 4.8849]. In Figure 3, the wage profile in the calibrated model is plotted with the actual wage profile in 1990.

5 Comparative Statics

This section provides the comparative statics with the model calibrated to the Japanese economy in 1990 in the previous section. I evaluate a steady state at the each year unemployment rate and calculate the slope of the wage profile in the steady state. Since the unemployment rate in this model is endogenous, it is impossible to impose it to some value directly. Thus, the value of μ is adjusted in order to the exact value of the unemployment. It is reasonable to adjust μ for unemployment rate because it reflects how difficult finding a job is. Of course, it is not trivial how μ affects the slope of the macro wage profile, that is, the change in μ does not determine directly how the slope changes.

In Figure 3, the model slopes which are evaluated in each steady state with the unemployment rate in each year are plotted with the actual data. Note that the plotted values of the slope are not time-series data produced by the model. It provides the results of the comparative statics to see how the slope in the steady state changes when the unemployment rate changes to the year t ($t = 1991, \cdots, 2000$).

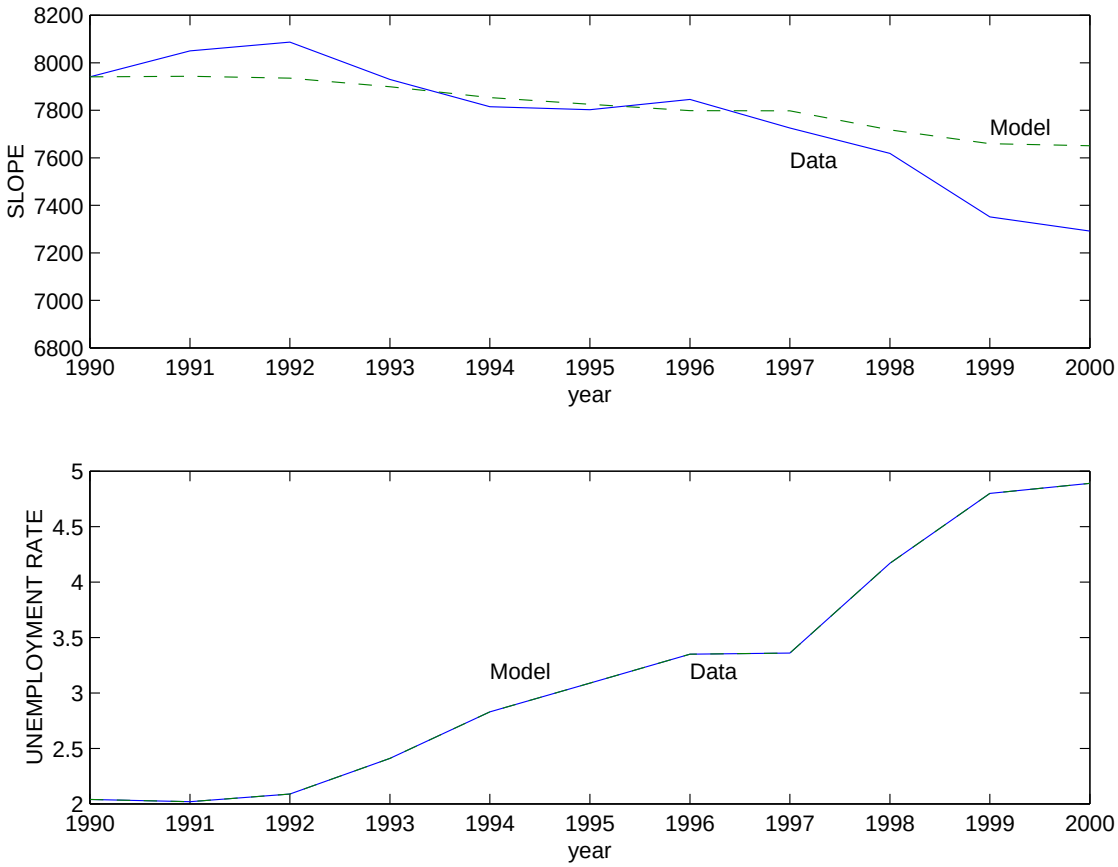

Figure 3 The slopes of the wage profile in the real data and the model

The values of μ used to produce the exact unemployment rates are shown in the Table 7. The changes in μ is very similar to that of the job-offers-to-seekers ratio, which is shown in Table 3 in section 1. By definition, the job-offers-to-seekers ratio reflects how difficult to get a job. Since the model is one-sided search, the vacancy is implicitly assumed to be supplied elastically, the difficulty of job hunting does not change endogenously. The exogenous variable μ reflects such a difficulty in this model. Therefore, the consistent changes in μ to the job-offers-to-seekers ratio implies the validity of the adjustment of μ.

In Japanese data, the slope has a negative trend in the 1990s. The comparative steady state analysis also infers that slopes in the late 1990s are lower than those in the early 1990s, based on the actual changes in the unemployment rate. Table 6 shows the correlation between the slopes and the unemployment rate in the model. It shows that the model captures the highly correlated relationship between them, although the correlation in the model is slightly higher than the data. It is clear from Table 7 that the decrease

Table 7 The Comparative Steady State Analysis

Year	1990	1991	1992	1993	1994	1995
UNEMP	2.04%	2.02%	2.09%	2.41%	2.83%	3.09%
Slope	7940.8	7943.2	7935.1	7899	7853.5	7825.2
μ	0.992	0.993	0.9897	0.975	0.9563	0.9446
$ASKILL_{whole}$	2.56	2.56	2.55	2.54	2.53	2.52
$ASKILL_1$	1	1	1	1	1	1
$ASKILL_2$	1.41	1.41	1.41	1.41	1.41	1.41
$ASKILL_3$	1.80	1.80	1.80	1.79	1.79	1.79
$ASKILL_4$	2.16	2.16	2.16	2.16	2.15	2.15
$ASKILL_5$	2.51	2.51	2.51	2.51	2.50	2.49
$ASKILL_6$	2.84	2.84	2.84	2.83	2.82	2.81
$ASKILL_7$	3.13	3.13	3.12	3.11	3.09	3.08
$ASKILL_8$	3.38	3.38	3.37	3.36	3.33	3.32
$ASKILL_9$	3.58	3.59	3.58	3.56	3.53	3.51
$ASKILL_{10}$	3.76	3.76	3.75	3.73	3.69	3.67
Year	1996	1997	1998	1999	2000	
UNEMP	3.35%	3.36%	4.17%	4.8%	4.89%	
Slope	7798.9	7797.9	7717.5	7659.1	7651	
μ	0.9336	0.9332	0.8992	0.874	0.8705	
$ASKILL_{whole}$	2.52	2.52	2.49	2.48	2.47	
$ASKILL_1$	1	1	1	1	1	
$ASKILL_2$	1.41	1.41	1.41	1.41	1.41	
$ASKILL_3$	1.79	1.79	1.79	1.78	1.78	
$ASKILL_4$	2.15	2.15	2.14	2.13	2.13	
$ASKILL_5$	2.49	2.49	2.47	2.46	2.46	
$ASKILL_6$	2.80	2.80	2.78	2.76	2.76	
$ASKILL_7$	3.07	3.07	3.04	3.02	3.01	
$ASKILL_8$	3.31	3.31	3.26	3.23	3.23	
$ASKILL_9$	3.50	3.50	3.45	3.41	3.40	
$ASKILL_{10}$	3.65	3.65	3.59	3.55	3.54	

in the slope is the result of the deterioration of the skill accumulation. The changes in average skill levels in age groups show how the skills in the economy accumulated.

All things considered, I can conclude that most of the changes in the slope in the 1990s are explained by the change in the unemployment rate.

6 Concluding Remarks

Many macro phenomena are affected differently by age groups. When we think about the time-consuming accumulation of skills, it is reasonable to imagine that decisions are substantially affected by one's age. The macro wage profile is one of the age related topics which can be understood by skill accumulation. There are much literature which investigate the wage profile considering the human capital accumulation on the job, for example Becker (1993) and Mincer(1974). This paper provides a basic model to directly analyze the macro wage profile in the context of the human capital accumulation on the job.

In the 1990s, the macro wage profile has become flatter while the unemployment rate increased in Japan. I investigated this phenomenon with an OLG model incorporating a search model in which workers accumulate skills on the job and lose skills during unemployment. It is claimed that the higher the unemployment rate is, the smaller the slope of the wage profile. The mechanism behind of this claim is that the increase in the unemployment rate leads the more losses of skills and the smaller number of workers who can accumulate their skills in the whole economy. In this paper, this mechanism is shown by numerical simulation.

In addition to the qualitative analysis, I examined the claim by applying the comparative statics to the model calibrated to the Japanese economy in 1990. I reported the slope evaluated in each stationary state associated with the unemployment rates in the 1990s. The analysis inferred correctly the relationship between the slope and the unemployment rate in the actual data. It means that the decline in the slope of the wage profile in the 1990s can be understood as the result of the deteriorated skill accumulation induced by the increase in the unemployment rate. The analysis also inferred that the average skill level in the whole economy decreased in the 1990s, because of the increase in the unemployment rate. This is consistent to preceding literature.

In future work, I plan to investigate the wage profile focusing on the heterogeneity of age more carefully. Although the drop in the wage profile in the old age groups are

understood as the effect of the mandatory retirement system, the model created small drop in the wage profile relative to the actual one. There exists a drop in the wage profile of the workers who have never experienced separation, too.[*8] Motivated by the data fact, I suspect that logic is needed to explain it. I also plan to analyze the mechanisms of other age heterogeneities in the labor market, for example, durations of unemployment spells, separation rate, and unemployment rate. I think these studies can bring about many implications to the real economy. They can be important in macro policy making, too.

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