Unemployment and the Wage Profile*

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January 7, 2005

Abstract

According to the human capital theory, an increase in the unemployment rate lowers the average skill level in the economy, because unemployment prevents workers from accumulating their human capital. In this paper, I analyze the average skill level by age group, in addition to the economy-wide one, by dealing with the macro wage profile. This is worth considering because the macro wage profile represents the average process of the human capital accumulation on the job, under the assumption that the amount of the human capital investments is stationary. This paper shows that, based on the human capital theory, the unemployment rate should be negatively related to the slope of the macro wage profile. To address this claim, I build an OLG model incorporating a search model in which workers accumulate skills when employed and lose them when unemployed. In addition, I apply the model to the Japanese economy in the 1990s as a case study.

Keywords: Wage profile, unemployment rate, human capital accumulation, overlapping generation, search, Japan.

JEL Classification Number: E24, J24

1 Introduction

Upward sloping wage profiles are prevailingly observed in many countries (see Koike (1995)), and many pieces of literature analyzed the steepness of the wage profile. Becker (1962) provided one of the most popular theories, which is called the human capital the-

* I am deeply grateful for encouragement and helpful advice from Dr. Braun (the University of Tokyo), Dr. Esteban-Pretel (the University of Tokyo), and Dr. Hayashi (the University of Tokyo). I am, nonetheless, solely responsible for any errors.

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ory. It claims that the steepness of the wage profile is explained by the amount of the investment in firm-specific human capital, and that larger investments in firm-specific human capital make wage profiles steeper.[*1] Several propositions induced by the human capital theory were supported by several empirical works. Hashimoto and Raisian (1985) examined the hypothesis that jobs with longer employment tenure will have more steeply sloped wage profiles. Mincer and Higuchi (1988) investigated the hypothesis that turnover is inversely related to tenure-wage growth.

However, the steepness of the wage profile is subject to the change not only in the amount of the firm-specific human capital investment, but also in the unemployment rate. This paper shows that an increase in the unemployment rate makes the wage profile flattened out because the increase implies the loss of skills and then a deterioration of the human capital accumulation. It is reasonable to imagine that workers lose their skills when separations occur, considering that some part of their skills is specific to the separated firm and that there is no chance to use or update their skills during unemployment spells. Actually, Mincer (1974) and Jacobson et.al. (1993) pointed out that the highly attached workers experience large and long-lasting earning losses after separation.

In this paper, I analyze the effect of the unemployment on the slope of the wage profile, in other words, the average human capital accumulating process. To make arguments clear, I keep unchanged the amount of the human capital investment over the analysis. Given a certain amount of the investment in the firm-specific human capital, that is, given certain rates of skill accumulation and deterioration, an average skill level in an age group gets lower as the number of workers who have experienced unemployment increases. Since this effect gets larger in older age groups, the slope of the macro wage profile[*2] gets smaller when the unemployment rate increases. There are many pieces of literature which analyze human capital accumulation along with the shocks, given a certain amount of the firm-specific human capital investment: for example, Ljungqvist and Sargent (1998), Pissarides (1992), and Esteban-Pretel (2003). 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 explicitly.

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

[*1] 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.

[*2] 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.

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".

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 profile is "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 with preceding literature, for example, Mincer (1974), Becker (1993), and Koike(1995).

Using the definitions above, we can see an interesting data fact in the Japanese labor market in the 1990s. During the period in Japan, the slope of the wage profile for males declined by 649 in real term, while the unemployment rate (male) approximately doubled, as shown in Table 1 and Figure 3.[*3] The negative relationship between the slope of the wage profile and the unemployment rate can be also seen in Table 2; the correlation coefficient is -0.968.

[*3] In the model provided in this paper, it is assumed that all workers who are not employed are assumed to search for a job and not to go to non-labor force. Namely, in the model, the not employed periods are equal to the unemployed periods. It seems to be reasonable to analyze the male workers in Japan with the representative agent model with the assumption above, given the stable labor force participation rate of them. On the other hand, the female labor force participation rate has an M-shaped form, and thus the assumption are not consistent with the characteristics of female data. (See "Labor Force Survey" Statistics Bureau, Management and Coordination Agency (MPHPT).) Therefore, I used only male data in the analysis in this paper.

Table 2　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.

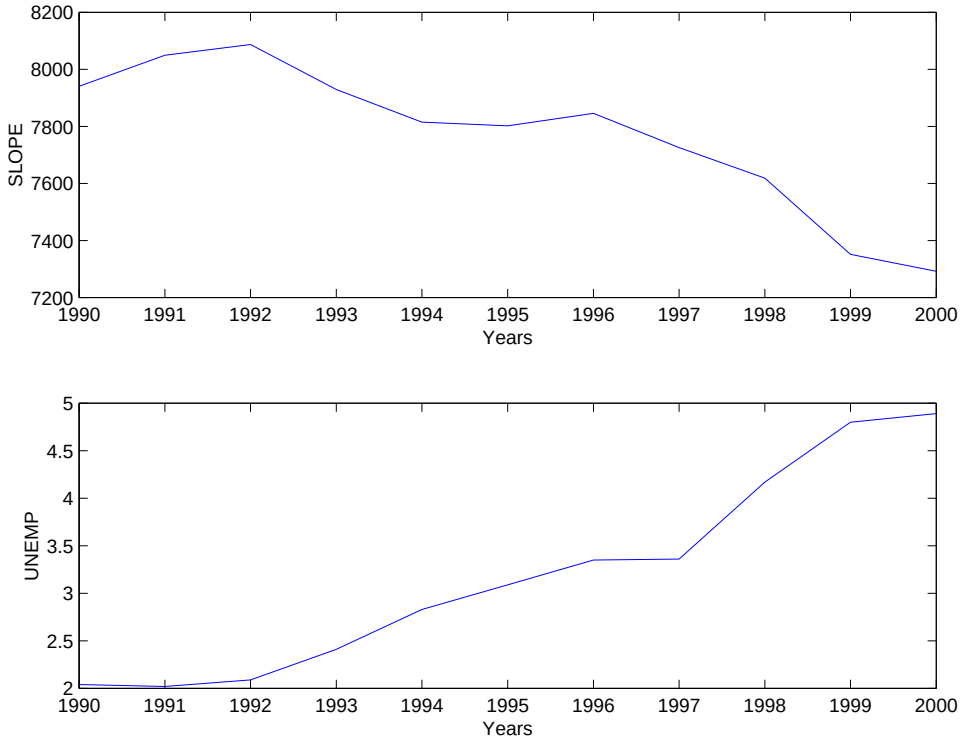

Figure 1　The SLOPE of the age-wage profileand Unemployement Rate (MALE)

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".

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."

In addition, we can see in Table 2 that the unemployment rate is also positively related to the job-offers-to-seekers ratio, whose values in the 1990s are shown in Table 3. The job-offers-to-seekers ratio indicates how many vacancies exist per unemployed people.[*4] 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 includes 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." [*5] The unemployment rates are from "Labor Force Survey (Rodoryoku Chosa), 1990-2000."

Motivated by the data fact in Japan, 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 increase in the unemployment rate make the wage profile flattened out.

We can alternatively argue other factors that probably make the wage profile flattened out. First, the decrease in the TFP growth rate worsened the macro economic performance,[*6] and therefore the training on the job was likely to be reduced. According to Becker (1993), the decrease in the training induces the decline in the steepness of the wage profile. Second, the technological change, for example, the advance in the

[*4] 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.

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

[*6] Hayashi and Prescott (2002) showed that the low TFP growth rate accounts for the stagnation of the Japanese economy in the 1990s.

information technology, invoked some changes in skills, deteriorated the skill accumulation in the transitional period, and then made the wage profile flattened out. Third, the aging demographic structure implies the relatively larger number of the skilled workers compared to that of the unskilled. Assuming the labor inputs of the skilled and unskilled workers are distinguished, the law of diminishing marginal productivity implies the marginal labor productivity, hence the wage, of the skilled worker decreases.[*7] Among many factors, however, I am focusing on the increase in the unemployment rate because it is the most visible factor.

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 efficiency unit 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 face a separation rate $\lambda \in (0,1)$, which is given

[*7] All of the factors listed here can also increase the unemployment.

exogenously in this model. For simplicity, I assume that all workers face the common value of λ no matter how old they are.

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 $\overline{h} = [1, 0, \cdots, 0]'$, 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 improves 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 the first period of unemployment, the worker's skill level follows the transition probability $\Phi_U(h, h')$ until he or her 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 Problem 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, he or she receives the labor income based on the accepted w and the worker's skill level until he or she gets separated. Therefore, the income at period $t + i$, 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.

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 $j(\neq N)$,

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

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

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

$$R^j h = c, \quad \text{for } j = N \tag{8}$$
$$\begin{aligned} &R^j h + \beta(1-\lambda)\sum_{h'}\Phi_E(h,h')V_E^j(R^j,h') \\ &\quad = c + \beta\sum_{h'}\Phi_U(h,h')V_U^{j+1}(h') - \beta\lambda\sum_{h'}\Phi_{SP}(h,h')V_U^{j+1}(h'), \text{ for } j \leq N-1. \end{aligned} \tag{9}$$

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 reservation wage.

2.3 Stationary Equilibrium

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

Definition

Given an exogenous efficiency unit wage distribution $F(\cdot)$, separation rate λ, the arrival rate of an offer μ, and Markov chain $(\Phi_i(i = E, SP, U), \overline{h})$, 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 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 stationary distribution $\Gamma(w, h, s, j)$ is induced by $(\Phi_i(i = E, SP, U), \overline{h})$, the separation rate λ, the arrival rate of an offer μ, and $\{R^j(\cdot)\}_{j=1}^N$.

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 the efficiency unit wage, 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. As in the previous section, I assume that all workers face the common value of λ no matter how old they are, for simplicity. I set λ to 0.22, which

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

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.

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.[*8] 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.

In the simulation, I found that the reservation wages are decreasing in age. That is, the older workers are, the more they are likely to accept an offer. On the other hand, the reservation wages are also decreasing in the skill level. Since the earning takes the form of wh, high skilled workers accept lower w than low skilled workers.

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 represent 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.[*9] This implies that we have to think about the number of periods of the model carefully when we consider the skill accumulation.

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

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

4 Calibration

In this section, I will calibrate the model to the Japanese economy in 1990; the model parameters are set to reproduce the wage profile and the unemployment rate in 1990. Because the wage data is shown by the age group of five ages, I set one model period to be five years; the number of the periods is 10. The discount rate for one year is set to 0.95, thus the discount factor for one period in thie model is 0.7738 ($= 0.95^5$). As I mentioned before, I assume that all workers face the common value of the separation rate, λ, no matter how old they are, for simplicity. λ is set in order that the model can produce the unemployment rates in the 1990s; the range of the unemployment rate varies according to λ.

The specification that the unit of the time is 5 years imposes that the unemployment duration in this model is longer than 5 years. In other words, this setting hinders analysis on the average unemployment duration. However, it does not have any harmful effect on the model or its outcomes, considering the objective of this paper. The objective is to analyze the negative relationship between the unemployment rate and the slope of the wage profile. Since the model parameters are set to reproduce the wage profile and the unemployment rate in 1990, other parameters are properly adjusted so that the model with 5 year specification captures the actual economy.[*10] The net change of the loss of the skills can be seized no matter how long the unit of the time is.[*11] In addition, this specification is a good choice, considering that the wage data have the information by the age group of 5 years but not by any age group of shorter years.

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

[*10] For example, the separation is less likely to occur in the model than the actual economy. In the steady state, the following relationship is satisfied: $u = F \times D$, where u, F, and D represents the unemployment rate, the separated workers to labor force ratio, and the average unemployment duration, respectively.

[*11] Based on the idea that upward wage profile is attributed to skill acquisition of workers, a set of parameters with which the model reproduce a wage profile in an economy captures the net change of the human capital in each age group in the economy. Hence, the set of parameters represents the skill accumulation process in the economy.

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

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.

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

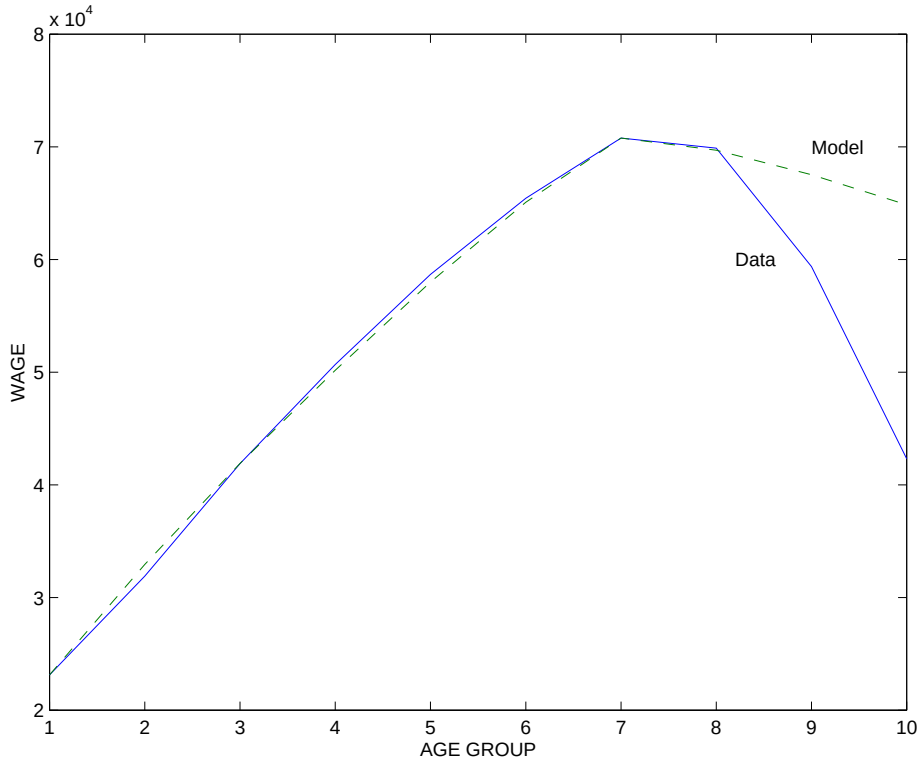

Figure 2 The Calibrated Wage Profile in Japan

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.

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 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. This analysis tells us what value the slope of the wage profile should be if a friction in the labor market is at the level of an compared year. Comparing with the data illustrates the effect of the unemployment rate on the wage profile.

The analysis consists of three steps. The first step is to calculate the slope of the wage profile in the steady state calibrated to the base year, 1990. The second step is to take up a compared year, change only the unemployment rate to the compared year's one by adjusting the value of μ, and re-calculate the slope of the wage profile in the steady state. The third step is to see the difference between the calculated slopes.

The reason of changing the unemployment rate by adjusting μ is that the unemployment rate in this model is endogenous and thus we cannot impose it to some value directly. It is reasonable to adjust μ for unemployment rate because it reflects how difficult finding a job is. In addition, assuming that the increase in μ is the main reason for that in the unemployment rate fits the situation of the Japanese economy in the 1990s, as discussed later. 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.

There are two main results provided by this analysis, which are summarized in Table 6. The first one is that the average skill level in the whole economy decreases as the unemployment rate increases due to the increase in μ. This result is consistent with the preceding literature, e.g. Pissarides(1992) and Ljungqvist and Sargent(1998). The second one is that the slope of the wage profile also decreases as the unemployment rate increases due to the increase in μ. The mechanism behind this result is that the increase in the unemployment rate decreases the average skill levels in every cohort and that the decrease is more outstanding in older age group. Namely, the increase in the unemployment rate worsens the average skill accumulation process in the economy and the slope of the wage profile reflects it.

Table 6 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	

Table 7 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

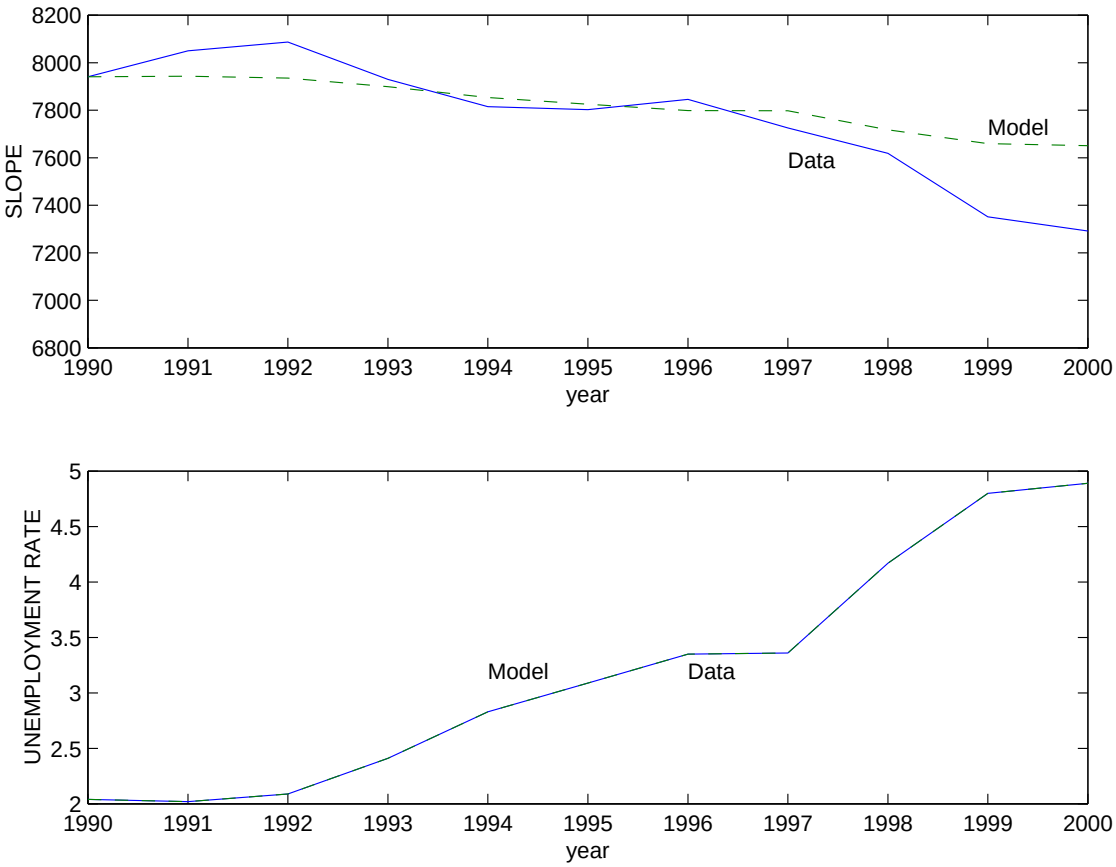

Figure 3 The slopes of the wage profile in the real data and the model

The values of μ used to produce the exact unemployment rates are shown in the Table 6. 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.

Based on the analysis, the increase in the unemployment rate was one of the major factors which flattened out the wage profile in the 1990s. The comparative steady state analysis infers that the slope of the wage profile is lower if a friction in the labor market is at the levels of the late 1990s than 1990. In the Japanese data, actually, the slope has a negative trend in the 1990s. In Figure 3, you can see the relationship between the actual data and the inference of the model visually. Note that the plotted values of the slope are not time-series data produced by the model. It just 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 ($t = 1991, \cdots, 2000$).

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 provided a basic model to directly analyze the negative relationship between the unemployment rate and the slope of the wage profile, in the context of the human capital accumulation on the job.

In this paper, I provided a story about the negative relationship between the unemployment rate and the slope of the wage profile, based on the human capital theory. The story was that an increase in the unemployment rate worsens the average skill accumulation process in the economy and then the slope of the wage profile decreases reflecting it. To address this hypothesis, I constructed an OLG model incorporating a search model in which workers accumulate skills on the job and lose skills during unemployment.

This model provided the two main claims. The first one is that the average skill level in the whole economy decreases as the unemployment rate increases. This is consistent with the preceding literature, e.g. Pissarides(1992) and Ljungqvist and Sargent(1998). The second one is that the slope of the wage profile also decreases as the unemployment rate increases. The mechanism behind is that the increase in the unemployment rate leads the average skill levels in every cohort and that the decrease is more outstanding in older age group. Namely, the increase in the unemployment rate worsens the average skill accumulation process in the economy and the slope of the wage profile reflects it.

In addition, I applied the model to the Japanese economy in the 1990s as a case study. I examined how the hypotetical effect of the unemployment appears in the actual data, by applying the comparative statics to the model calibrated to the Japanese economy in 1990. The results of the analysis showed that the increase in the unemployment rate was one of the major factors which flattened out the wage profile in the 1990s. In the Japanese data, actually, the slope of the wage profile decreased while the unemployment rate increased in the period.

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. In addition, there exists a drop in the wage profile of the workers who have never experienced separation, too.[*12] 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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