What is Firm-Specific Human Capital?

A Model of *Firm-Specific* Combinations of *General* Skills Generated by History-Dependent Task Assignment Processes

November 2005

Shigeru Wakita

Faculty of Economics, Tokyo Metropolitan University
1-1 Minami-Osawa, Hachioji-shi, Tokyo, Japan 192-0397
wakita@bcomp.metro-u.ac.jp

This paper examines the nature of firm-specific human capital and proposes a new model in which firm-specific human capital is seen as different combinations of skills generated by history-dependent task-assignment processes. By introducing multiskilled training, the model shows that workers' combinations of skills are determined by firms' training policies, and that different combinations of skills emerge in different firms. Thus, the firm offers workers *general* training in *firm-specific* combinations of skills. The model is dynamic and determines the conditions under which the firm's choice converges to a specific combination of skills, which affects job turnover.

* The author would like to thank Kazuo Koike for his valuable comments, and Isao Ohashi and Konosuke Odaka for their encouragements. This paper was partially supported by the Japan Center for Economic Research and the Grant-in-Aid for the 21st Century COE program from the Ministry of Education, Culture, Sports, Science and Technology of Japan.

I. Introduction

What is firm-specific human capital? This question has been asked since the publication of the classic work, “Human Capital”, by Becker (1957). This paper examines the nature of firm-specific human capital and develops a new model in which firm-specific human capital is seen as different combinations of skills, which are generated by history-dependent task-assignment processes. By introducing multiskilled training, we show that workers’ combinations of skills are determined by firms’ training policies, and that different combinations of skills emerge in different firms. Thus, the firm offers workers *general* training in *firm-specific* combinations of skills. The model is dynamic and determines the conditions under which the firm’s choice converges to a specific combination of skills, which affects job turnover.

Since the concept of firm-specific training was pioneered by Becker (1957), various studies have incorporated and developed it. However, the nature of firm-specific human capital has not been fully explored. Becker (1957) defined general training and specific training as follows.

> Completely general training increases the marginal productivity of trainees by exactly the same amount in the firms providing the training as in other firms. Clearly some kinds of training increase productivity by different amounts in the firms providing the training and in other firms. Training that increases productivity more in firms providing it will be called specific training. Completely specific training can be defined as training that has no effect on the productivity of trainees that would be useful in other firms.

Although this definition is clear, the nature of firm-specific training (investment) has not been fully explored. Becker (1957) offered as examples of specific training (a) military training, (b) resources spent by firms in familiarizing new employees with their organizations, and (c) expenditure on acquiring knowledge of employees’ talents.

Doeringer and Piore (1971) have offered a more detailed explanation. They stressed the effect of “technology specificity” on the formation of internal labor markets, and stated that “operators familiar with the idiosyncrasies of the particular pieces of equipment can produce much faster and are also able to anticipate machine breakdown, thereby minimizing equipment downtime." They also stated that: "These skills are highly specific in character."

Koike (1981, 1988) offered another explanation of firm-specific human capital.[1] His argument differs from that of Doeringer and Piore (1971) and is based on the prevailing job rotation system in Japan. Koike (1988) stated that:

> In contrast, my theory demonstrates that enterprise-specific skills are mainly the outcome of the way in which careers are formed. Granted that the content of individual jobs may be similar in competitive companies, there can still be depending on each company a variety of ways of forming a job career: specifically which sort of jobs should be experienced and in what order.

Koike (1988) presented evidence of differences in job mobility within a large Japanese steel company (Table 1).

The model developed in this paper is motivated by Koike' s insight; workers' specificity is determined from the different ways in which a career can be formed. To illustrate the idea, suppose that two professors (*a* and *b*) must teach four classes (microeconomics, macroeconomics, econometrics, and mathematics) in a graduate school. Professor *a* can teach macroeconomics and econometrics, while Professor *b* can teach microeconomics and mathematics. If professor *b* leaves the school, the vacancy should be filled by a professor who can teach microeconomics and mathematics. Thus, the successor should have the same skill combination as his or her predecessor. In another school, the combination pairs could be macroeconomics and microeconomics, and mathematics and econometrics. Thus, different combinations are possible for a given set of general skills.

---

1 Carmichael and McLeod (1993) considered multiskilled training in Japan to enhance workers' cooperative incentives. Park (1996) described various aspects of multiskilled employment.

Table 1

Mobility within a workshop (Large Japanese Steel Company)

	Yawata	Hikari	Hirohata	Sakai	Nagoya	Kimitsu	Kamaishi	Muroran
Blast furnace charging	-		*	-	○	*	○	○
Stove operation	+		*	-	□	*	○	○
Coke oven operation	+		□		○		□	○
Steel converter operation	□	*	-	□	○	-	*	□
Steel pouring	□		○	□	○	-	+	*
Reheating furnace operation, hot strip mill	□		□	□	□	□		*
Hot strip finishing mill operation	□		*	□	□	*		○
Plate finishing mill operation			*					
Crane operation			-	○	○	-	○	-
Cold strip mill operation	+		+		□	□		
Pipe mill operation		□						
Gilding	+		□		□			
Boilers engine room	□	□	*	□	○	-	-	-
Analysis		□		-		□	-	-
DL driving	*		*		○		*	-

Note: ○ Regular rotation to all positions in the workshop
* Rotation to all positions, not regularly
□ Partial rotation
+ No rotation
- No reference to rotation

Source: Shinnittetsu Rodokumiai (Nippon Steel Confederation of Trade Unions) Chosa Jiho (Bulletin) August 1971, Reprinted from Understanding Industrial Relations in Japan p. 132

This example shows that specific combinations of general skills produce worker specificity. However, the emergence of specific skill combinations in the above example depends on the indivisibility of workers, that is, on the assumption of four tasks and two workers. Large companies hire many workers, and therefore, many more combinations are possible. If the school hires six teachers, all possible combinations can be employed. Moreover, firm-specific human capital is formed as a result of training within firms while the graduate school example considers the matching problem among different types of workers given exogenous skills.

Hence, the model developed in this paper introduces two additional factors into the story: training provided by firms has an uncertain return; and teachers play a role in senior skilled workers producing history-dependent task-assignment processes (Rosen (1978) and Sattinger (1993)).

These two factors are important to develop a model because recent model by Lazear

(2003) considered the similar idea, called a skill-weight approach of firm-specific human capital. In his model, workers get two skills whose weights are different, and specific to the firm. He argued this approach is consistent with the various empirical evidence. The weights of skills, however, are *exogenously* determined in his static model while the combinations of skills are *endogenously* determined in our dynamic model by introducing these two factors.

One might argue that differences in skill combinations between firms are minimal, and consequently, that the model's explanation of firm-specific human capital is weak. However, the main problem in the context of firm-specific human capital relates to matching vacancies and applicants. It is not necessary, however, that different characteristics involve well-defined workplace skills. Rather, imperfect knowledge or IT ability, for example, might generate countless specific worker characteristics. Further, combination formula suggests that relatively few elements generates a large number of different combinations. The model developed in this paper shows that differences in characteristics emerge endogenously among *ex ante* identical workers.

The next section describes the model. The final section offers concluding remarks.

II. The Model

We consider a representative firm in a competitive industry and *ex ante* homogeneous workers in a two-period overlapping-generations economy, in which "young" and "old" workers exist in each period. Workers are trained when young to acquire skills for performing specific operations, with the probability θ; untrained workers do not acquire these skills. In old age, both workers and firms benefit from training.

The firm has the following Leontief production function with four operations *A*, *B*, *C*, *D*:

$$X_t = \min\,[\beta L_{At}, \beta L_{Bt}, \beta L_{Ct}, \beta L_{Dt}], \tag{1}$$

where X_t is output, β is the labor coefficient, L_{At}, L_{Bt}, L_{Ct} and L_{Dt} are the amounts of labor implied by the efficiency unit assigned to operations *A*, *B*, *C*, and *D*, respectively, which are given by:

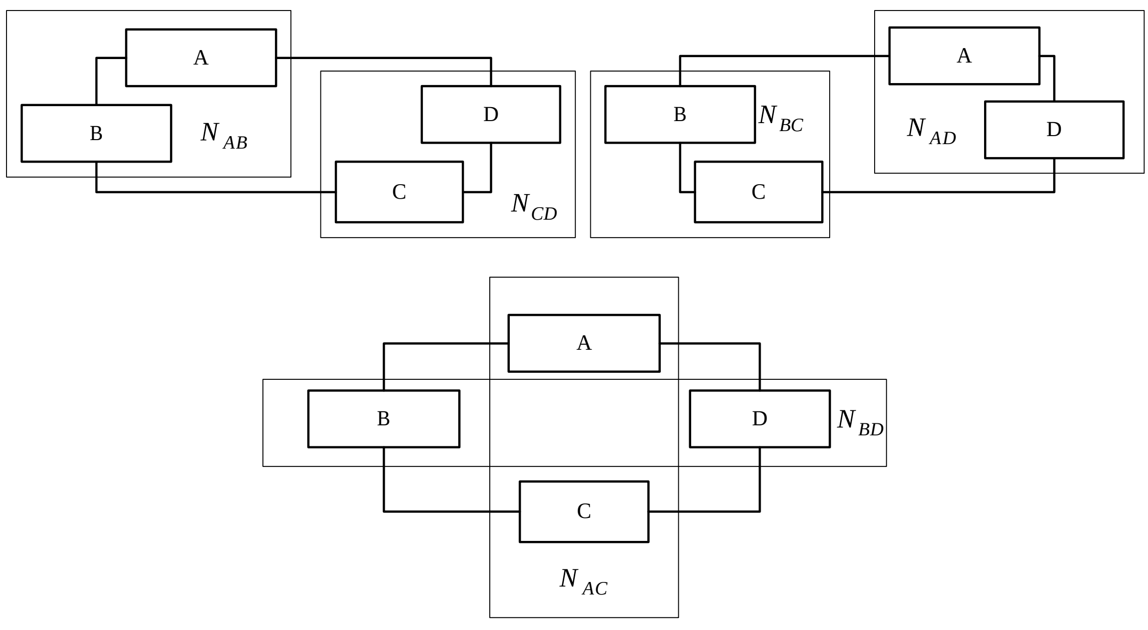

Fig. 1. Workers' training: the case of four operations and two skills

$$L_{jt} = L_{2jt} + L_{3jt} + (1+a)L_{1jt} \quad j = A,B,C,D, \tag{2}$$

where a is productivity parameter of skilled workers, and subscripts 1 denoted old skilled workers, 2 young workers, and 3 old unskilled workers.

Each worker is trained to perform two operations simultaneously when they are young. They continue to work in their assigned operations in youth and old age whether or not they acquire skills. To analyze the process explicitly, the number of operations in the production process is restricted to *four* and the number of skills to *two*. Thus, from the formula, ${}_nC_q = \dfrac{n!}{(n-q)!q!}$, there are six types of skill combination.[2]

Therefore, as Figure 1 illustrates, workers are classified by operation, skill acquisition, and age, as follows:

$$N_{2kt} = \delta_{kt} N_t \tag{3}$$

$$N_{1kt+1} = \theta_{kt} N_{2kt} \tag{4}$$

$$N_{3kt+1} = (1-\theta_{kt}) N_{2kt} \quad k = AB, AC, AD, BC, BD, CD, \tag{5}$$

where δ_k is the allocation ratio of workers into the k-th skill group. Thus, L_{2At} is consist of the sum of N_{2ABt}, N_{2ACt} and N_{2ADt}.

We focus on the case in which $N_{iABt} = N_{iCDt}$, $N_{iACt} = N_{iBDt}$ and $N_{iADt} = N_{iBCt}$ so that skill combinations are classified into *three* groups. We consider changes in these three groups, which are henceforth termed "skill groups".

The probability of skill acquisition, θ_{kt}, is described by the following skill-formation function:

2 Important models related to the division of labor have been proposed by Rosen (1978) and others; see, e.g., Sattinger (1993) for a comprehensive survey. That is, using the characteristics approach of Gorman (1980) and Lancaster (1966, 1979), the matching problem of workers' different "bundles" of characteristics has been analyzed. This literature, however, has only considered the *static* assignment problem with *exogenous* types of skill distribution within the framework of *deterministic* partial equilibrium.

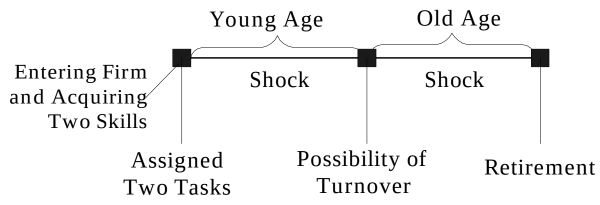

Fig. 2 Timing assumption

$$\theta_{kt} = T_{kt}^{\ \alpha} \left(\frac{\xi_{kt} N_{1kt}^{\ \varepsilon}}{N_{2kt}} \right)^{\beta}, \tag{6}$$

where θ_{kt} denotes the probability of successful skill acquisition by the *k-th* skill group of unskilled young workers. This probability is an increasing function of training cost T_{kt} for the *k*-th combination of skills as well as the number of incumbent skilled workers N_{1kt} who provide the on-the-job training. We assume that the specific skill group of incumbent workers passes on all its skills to young workers so that trainers and trainees belong to the same skill group.[3] This is an important assumption and implies that task-assignment processes are historically dependent. ξ_{kt} denotes a independent and identically distributed stochastic shock for the *k*-th skill group of workers. To simplify the analysis, we assume that $\xi_{ABt} = \xi_{CDt}$, $\xi_{ACt} = \xi_{BDt}$ and $\xi_{ADt} = \xi_{BCt}$.

Workers' preferences

We assume that workers have von Neumann-Morgenstern utility functions, which depend only on wages, *W*, as follows:

$$u(\cdot)=u(W)\ ,\ u'>0\ ,\ u''<0. \tag{7}$$

This equation implies that workers are risk averse. Workers aim to maximize expected discounted utility, which is:

3 Athey et al. (2000) considered the case of senior workers playing the role of providers of on-the-job training.

$$U_t\ [\equiv \sum_k \delta_{kt}(\ u(W_{2kt})+\rho\theta_{kt}u(W_{1kt+1}) +\rho(1-\theta_{kt})u(W_{3kt+1}))] = \overline{V} \tag{8}$$

where W_{2kt} is the wage rate of the k-th skill group of young unskilled workers in period t. In addition, W_{1kt+1} is the corresponding wage rate of old skilled workers, W_{3kt+1} denotes that of old unskilled workers, and ρ is a discount factor, which is constant over time. The workers' reservation utility $\overline{V}$ is a market-determined level of expected utility that workers can obtain by accepting jobs with other firms. Wage profiles are contracted once at the beginning of the period, and are enforceable on the basis of firms' reputations. The possibility of job turnover is discussed later.

Let δ_k be the allocation ratio of workers into the k-th skill group, related to which is the following adding-up constraint:

$$\sum_k \delta_{kt} = 1. \tag{9}$$

The firm's cost-minimization problem

The firm's cost-minimization problem is:

$$\min_{\delta_{kt}, N_t, T_{kt}, W_{ikt}, \lambda_{wt}, \lambda_{rt}, \lambda_{jt}} E_0 \sum_{t=0}^{\infty} \rho^t C_t \tag{10}$$

This is solved subject to (1) to (9) and $N_{1k0} = \overline{N}_{1k0}$, where:

$$C_t \equiv \sum_{i=1}^{3} \sum_k W_{ikt} N_{ikt} + \left(\sum_k T_{kt}\right) N_t\,. \tag{11}$$

Note that T_{kt} is defined as training cost per N_t, not N_{2kt}.

Substituting in (2) to (6) and denoting λ_{wt}, λ_{rt} and λ_{jt} as the Lagrange multipliers associated with (8), (9), and (5), respectively, the Lagrangean is as follows:

$$\sum_{t=0}^{\infty} \Big(\rho^t C_t + \lambda_{wt}[\overline{V} - U_t] + \lambda_{rt}(\sum_k \delta_{kt} - 1) + \sum_j \lambda_{jt}\left[X_t - \beta L_{jt}\right]\Big). \tag{12}$$

The first-order necessary conditions are examined in sequence.

Wage determination

Before explaining the dynamics of training, we focus on wage determination. The optimal contract for wage determination is a simple application of implicit contract theory because workers are *ex ante* identical, and the firm assigns operations to workers at random. Differentiating (12) with respect to W_{it} yields the optimal condition for the wage of the *k-th* worker when young, which is:

$$\delta_{kt}N_{2t}-\lambda_{wt}\delta_{kt}u'(W_{2kt})=0, \tag{13}$$

Similarly, those for skilled and unskilled workers into old age are:

$$\rho\delta_{kt}\theta_{kt}N_{2t}-\lambda_{wt}\rho\delta_{kt}\theta_{kt}u'(W_{1kt+1})=0, \tag{14}$$

$$\rho\delta_{kt}(1-\theta_{kt})N_{2t}-\lambda_{wt}\rho\delta_{kt}(1-\theta_{kt})u'(W_{3kt+1})=0. \tag{15}$$

The Lagrange multiplier λ_{wt} is the same for all operations, and therefore, wages are smoothed. Wages are the same for different operations and skill groups of workers because workers have identical utility functions. That is:

$$W_{1t}=W_{1t+1}=W_{2t}=W_{2t+1}=\cdots\equiv W_t^* \tag{16}$$

where W_t^* is the optimal wage rate.

The above analysis indicates that firms insure workers against all stochastic fluctuations in the real marginal product of labor if no effort is required for skill acquisition. In other words, implicit contract theory (see Azariadis (1975), Baily (1974)) focuses on stochastic fluctuations in demand. We also analyze fluctuations in the marginal product of labor. Thus, we expect to get this result from the implicit-contract-theory framework. This type of ability insurance has been studied by Harris and Holmstrom (1982).

Training expenditure

From the property of Leontief function, the Lagrange multipliers on the constraint derived from production function are:

$$\lambda_{jt}=\lambda_t. \quad \forall j, \forall t \tag{17}$$

Note that this equality implies that the number of efficiency units of labor assigned to operation *j*, L_j, is the same for all groups.

Using (17) and the result of implicit wage contracting, given by (16), the first-order necessary conditions are as follows:

$$\delta_{kt}\text{:}\quad 2a\beta(2\beta-1)\lambda_{t+1}N_t T_{kt}{}^{\alpha}\frac{(\theta_{kt-1}\delta_{kt-1}N_{t-1})^{\beta\varepsilon}\xi_{kt}{}^{\beta}}{N_t{}^{\beta-1}\delta_{kt}{}^{\beta}}-\lambda_{rt}+2N_t\left[\sum_k T_{kt}+W_t*(1+\rho)-\beta(\lambda_t+\lambda_{t+1})\right]=0, \tag{18}$$

$$T_{kt}\text{:}\qquad 2N_t\left[1-a\alpha\beta\frac{(N_{t-1}\delta_{kt-1}\theta_{kt-1})^{\beta\varepsilon}\xi_{kt}{}^{\beta}}{N_t{}^{\beta}\delta_{kt}{}^{\beta-1}}T_{kt}{}^{\alpha-1}\lambda_{t+1}\right]=0, \tag{19}$$

$$N_t\text{:}\qquad a\beta(\beta-1)\left[\sum_k T_{kt}+W_t*(1+\rho)-\beta(\lambda_t+\lambda_{t+1})\right]\lambda_{t+1}\frac{N_{t+1}{}^{\beta\varepsilon}}{N_t{}^{\beta}}\sum_k(\delta_{kt-1}\theta_{kt-1})^{\beta\varepsilon}\delta_{kt}{}^{1-\beta}\xi_{kt}{}^{\beta}T_{kt}{}^{\alpha}=0 \tag{20}$$

From (18) to (20) and definitions (6) and (9), we get:

$$\delta_{jt}=\frac{\left(\delta_{jt-1}{}^{\varepsilon}\xi_{jt}\right)^{\beta/(\beta-\alpha)}}{\sum_k\left(\delta_{kt-1}\right)^{\beta\varepsilon/(\beta-\alpha)}\xi_{kt}{}^{\beta/(\beta-\alpha)}} \tag{21}$$

(see Appendix). This equation indicates that δ_{kt} follows a simple first-order difference equation. Furthermore, taking logarithms, and subtracting the equation for one skill group from another, we get:

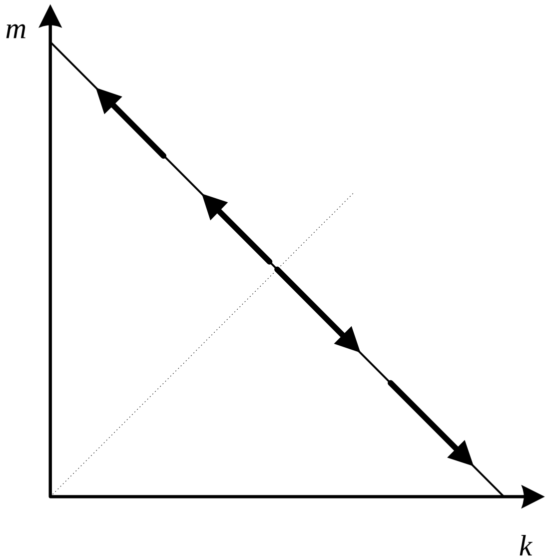

Fig. 3. Production possibility frontier

with two skill groups *k* and *m*

$$\log(\delta_{kt})-\log(\delta_{mt})=\frac{\beta\varepsilon}{\beta-\alpha}\left(\log(\delta_{kt-1})-\log(\delta_{mt-1})\right)+\frac{\beta}{\beta-\alpha}\left(\log(\xi_{kt-1})-\log(\xi_{mt-1})\right). \qquad (22)$$

In any combination of skill groups of workers, the ratio between two skill groups, *k* and *m*, is described by this first-order linear difference equation.

If $\frac{\beta\varepsilon}{\beta-\alpha}>1$, the first-order stochastic linear difference equation above is explosive, and hence, the equilibrium ratio is unstable; the difference between δ_k and δ_m increases to its maximum over time, as shown in Figure 3. One ratio goes to unity while the other goes to zero. This implies that only one skill group survives.

From the definition of the training function, (6), $\theta_{ABt}=T_{kt}{}^{\alpha}\left(\frac{\xi_{kt}N_{1kt}{}^{\varepsilon}}{N_{2kt}}\right)^{\beta}$; the larger are α and γ, the more likely is an explosive path and the more likely is training to be biased. The larger is β, the less likely are an explosive path and biased training because $\partial\left(\frac{\beta\varepsilon}{\beta-\alpha}\right)\Big/\partial\beta<0$. This may seem counterintuitive. The reason behind this result is that the risk-neutral firm takes advantage of a greater number of skilled workers by increasing training costs.

Turnover possibilities

The model describes the possibility of an explosive path for the linear difference equation. Such a path implies that the firm's specific combinations of skills are affected by the initial allocation. Returning to the graduate school example, the model shows that the school has a specific combination of skills if the school itself trains a large number of teachers. Although the model limits the number of skill combinations to six for simplicity, we can easily extend the model to allow for many skill groups of workers. Then, the problem of matching workers' skills and firms' requirements is exacerbated.

In this model, Leontief technology requires that job turnover should arise within groups to prevent production loss. If a multiskilled worker who can do jobs *A* and *B* is employable by other firms, the firm would try to hire workers to do *A* and *B*. Otherwise the worker would swap jobs with another worker who can do jobs *C* and *D*. Thus, turnover is less likely the greater the number of operations.

III. Conclusion

The model presented in this paper has described the nature of firm-specific human capital. Firm-specific human capital is seen as different firm-specific combinations of general skills, generated by history-dependent task-assignment processes. By introducing multiskilled training, workers' combinations of skills differ between firms. The model showed that a firm offers general training in firm-specific combinations of skills. We used the model to determine the conditions under which a balanced combination path is unstable and converges to a specific combination of skills within a firm.

This history-dependent assignment process generates cultural differences between nations. Consider differences in eating habits between ethnic groups. Superficial differences seem clear, but combinations of attributes (nutrition) from different habits are similar nutritionally. Therefore, our model can be interpreted as a dynamic extension of the hedonic approach (Lancaster (1966) and Rosen (1974)) and has profound implications for simple explanations of firm-specific human capital.

Appendix

Rearranging (18) yields:

$$T_{kt}=\left[\frac{\lambda_{rt}-2N_t Lcost_t}{2a\beta(2\beta-1)N_t\lambda_{t+1}}\left(\frac{\xi_{kt}N_t\delta_{kt}}{\left(N_{t-1}\delta_{kt-1}\theta_{kt-1}\right)^{\varepsilon}}\right)^{\beta}\right]^{\frac{1}{\alpha}}, \tag{B1}$$

where $Lcost_t \equiv \sum_k T_{kt}+W_t*(1+\rho)-\beta(\lambda_t+\lambda_{t+1})$. Eliminating λ_t from (18) and (19) yields:

$$\delta_{kt}=\left[T_{kt}{}^{\alpha-1}a\,\alpha\beta\lambda_{t+1}\left(\frac{\xi_{kt}\left(\delta_{kt-1}\theta_{kt-1}N_{t-1}\right)^{\varepsilon}}{N_t}\right)^{\beta}\right]^{\frac{1}{\beta-1}}. \tag{B2}$$

Inserting (B1) into the skill-formation function (6) yields:

$$\delta_{kt}=\frac{2a\beta(2\beta-1)N_t\Theta_{kt}\lambda_{t+1}}{\lambda_{rt}-2N_t Lcost_t}, \tag{B3}$$

where $\Theta_{kt}\equiv\theta_{kt}\delta_{kt}$. Inserting (B1) to (B3) into (20) yields:

$$Lcost_t=\frac{(1-\beta)\lambda_{rt}}{2N_t\beta} \tag{B4}$$

Substituting (B3) into the adding-up constraint (9) yields:

$$\lambda_{rt}=2N_t\left[Lcost+2a\beta\left(2\beta-1\right)\lambda_{t+1}\left(\Theta_{ABt}+\Theta_{ACt}+\Theta_{ADt}\right)\right]. \tag{B5}$$

Inserting (B5) into (B3) yields:

$$\delta_{kt}=\frac{\Theta_{kt}}{2\left(\Theta_{ABt}+\Theta_{ACt}+\Theta_{ADt}\right)}. \tag{B6}$$

Combining (B2) and (B6) yields:

$$\frac{\Theta_{kt}}{2\left(\Theta_{ABt}+\Theta_{ACt}+\Theta_{ADt}\right)}=\left[T_{kt}{}^{\alpha-1}a\,\alpha\beta\lambda_{t+1}\left(\frac{\xi_{kt}\left(\Theta_{kt-1}N_{t-1}\right)^{\varepsilon}}{N_t}\right)^{\beta}\right]^{\frac{1}{\beta-1}}. \tag{B7}$$

Inserting (B1), (B4) and (B5) into (B7) yields:

$$\Theta_{jt}=\frac{\left(\Theta_{jt-1}{}^{\varepsilon}\xi_{jt}\right)^{\beta/(\beta-\alpha)}\sum_k\left(\Theta_{kt}\right)}{\sum_k\left(\Theta_{kt-1}\right)^{\beta\varepsilon/(\beta-\alpha)}\xi_{kt}{}^{\beta/(\beta-\alpha)}}. \tag{B8}$$

References

Athey, S., Avery, C. and Zemsky, P. (2000) “Mentoring and Diversity,” *American Economic Review* 90-4 765–86.

Azariadis, C. (1975) “Implicit Contracts and Underemployment Equilibria,” *Journal of Political Economy* 83, 1183–1202.

Baily, M. N. (1974) “Wages and Employment Under Uncertain Demand,” *Review of Economic Studies* 41, 37–50.

Becker, G. S. (1957) *Human Capital*, The University of Chicago Press.

Carmichael, H. L. and McLeod, W. B., (1993) “Multiskilling, Technical Change and the Japanese Firm,” *Economic Journal* 103–416, 142–60.

Doeringer, P.B. and Piore, M.J. (1971) *Internal Labor Markets and Manpower Analysis*, M.E. Shape, Inc.

Gorman, W. M., (1980) “A Possible Procedure for Analysing Quality Differentials in the Egg Market,” *Review of Economic Studies* 843-56.

Harris, M. and Holmstrom, B. (1982) “A Theory of Wage Dynamics,” *Review of Economic Studies* 49, 315-33.

Koike, K. (1981) *Nihon no Jukuren* [Japanese Workers’ Skill], Yuuhikaku.

Koike, K. (1988) *Understanding Industrial Relations in Modern Japan*, St. Martin's Press.

Lancaster, K. (1966) “A New Approach to Consumer Theory,” *Journal of Political Economy*, 132–57.

Lazear, E. (2003) “Firm-Specific Human Capital: A Skill-Weights Approach,” *NBER Working Paper*, No. 9679.

Park, K. S. (1996) "Economic Growth and Multiskilled Workers in Manufacturing" *Journal of Labor Economics* 14–2 254–85.

Rosen, S. (1974) “Hedonic Prices and Implicit Markets: Product Differentiation in Pure Competition,” *Journal of Political Economy* 82, 34–55.

Rosen, S. (1978) “Substitution and Division of Labour,” *Economica* 235–50.

Sattinger, M. (1993) “Assignment Models of the Distribution of Earnings,” *Journal of Economic Literature* 31-2, 831–80.