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New implications of Lazear's skill-weights approach[☆]

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ABSTRACT

A new approach to the theory of specific human capital, proposed by Lazear (2009), assumes that all skills are general but that firms use them with different weights attached. In Lazear's analysis, the decision to invest in the worker's acquisition of various skills is assumed to maximize the expected net joint surplus of the worker and the employer. This paper explores new implications of the skill-weights approach when the worker and the firm independently and non-cooperatively invest in the worker's skills.

1. Introduction

Since the seminal contribution by Becker (1962), the distinction between general and firm-specific human capital has played an important role in the analysis of human capital acquisition. Firm-specific human capital raises the productivity of the worker at his current firm but not elsewhere, whereas general human capital increases the worker's productivity at his current firm *and* at other firms. Lazear (2009) has recently proposed a broader approach to the theory of human capital, called the skill-weights approach, that does not rely on the dichotomy of general versus specific human capital. In his approach, all skills are general but firms use them with different weights attached. It can be summarized as follows: Lazear considers a two-period model in which there are two skills, skills A and B, that the individual can acquire at cost $C(x_A, x_B)$. The output of a worker with skill set (x_A, x_B) at firm i is given by $y_i = \lambda_i x_A + (1 - \lambda_i) x_B$, where x_A denotes the level of the worker's skill A, x_B denotes the level of skill B, and $\lambda_i \in [0, 1]$. The skill-weight, λ_i, reflects the idea that each firm i may weight the skills differently from another firm j. Lazear demonstrated that the skill-weights approach yields many of the implications of the traditional approach to human capital acquisition, and offers a number of new testable implications.[1]

In Lazear's analysis, the decision to invest in the worker's two types of skills is assumed to maximize the expected net joint surplus of the worker and the firm. This approach is consistent with Becker's (1962) analysis, which implicitly assumes that a worker and firm can sign an enforceable contract that specifies investment levels in general and specific human capital.[2] However, as Gibbons and Waldman (1999) point out, an equally useful approach would assume that investment levels are not contractible. Motivated by that observation, this paper analyzes a simplified extension of the skill-weights model in which the firm and the worker independently and non-cooperatively invest in the two types of skills, and discusses new implications of the skill-weights approach that arise from that alternative assumption.

2. The model

Consider a two-period model, and let there be two skills, A and B. Period 1 is the skill-acquisition period, and period 2 is the production period. The output of a worker with skill set (x_A, x_B) at firm i is given by $y_i = \lambda_i x_A + (1 - \lambda_i) x_B$, where x_A denotes the level of the worker's skill A, x_B denotes the level of skill B, and $\lambda_i \in [0, 1]$. There are two firms, 1 and 2. Assume, without loss of generality, that $1 \geq \lambda_1 > \lambda_2 \geq 0$; that is, firm 1 puts more weight on skill A and less

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1 For example, as markets become thicker – such that the worker receives more offers from alternative employers – the wage gain from quitting goes to zero and the wage loss associated with involuntary turnover decreases. This is not an implication of standard specific human capital models.

2 Becker also implicitly assumes that they can sign a contract that specifies wages, whereas Lazear assumes that post-training wages are determined by bargaining.

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weight on skill B than firm 2. To keep the analysis simple, the firms and the worker do not discount the future.

Consider a worker initially employed by firm 1. In period 1, firm 1 can provide the worker with certain levels of skills A and B, denoted by a_1 (≥ 0) and b_1 (≥ 0), respectively, by incurring costs $C_A(a_1)$ and $C_B(b_1)$, respectively, where $C_A(.)$ and $C_B(.)$ are convex cost functions. The worker can also acquire certain levels of skills A and B, denoted by a_w (≥ 0) and b_w (≥ 0), respectively, at costs of $C_A(a_w)$ and $C_B(b_w)$, respectively.[3] At the end of period 1, the levels of the worker's skills A and B are $x_A = a_1 + a_w$ and $x_B = b_1 + b_w$, respectively. To obtain closed-form solutions, let $C_A(a_j) = \frac{1}{2}a_j^2$ and $C_B(b_j) = \frac{1}{2}b_j^2$ where $j = 1, w$.

The timing of moves in the game is as follows:

Period 1:

[Stage 1] Firm 1 and the worker simultaneously and non-cooperatively choose (a_1, b_1) and (a_w, b_w), respectively, where firm 1 and the worker incur costs $C_A(a_1) + C_B(b_1)$ and $C_A(a_w) + C_B(b_w)$, respectively.[4]

Period 2:

[Stage 2] Following Lazear (2009), we assume that the wage during period 2 is determined according to a Nash bargaining framework. That is, the worker stays with firm 1 if $y_1 \geq y_2$ and moves to firm 2 if $y_1 < y_2$ and the worker's second-period wage, denoted by w_2, is determined so that the worker and his second-period employer split the rent equally; $w_2 = \frac{y_1+y_2}{2}$.

[Stage 3] The worker produces output of $y_k = \lambda_k x_A + (1 - \lambda_k)x_B$, where $x_A = a_1 + a_w$ and $x_B = b_1 + b_w$ at her period-2 employer firm k ($=1$ or 2).

Main differences between Lazear's model and our extension

- In Lazear's model, investments in the two types of skills are assumed to be made at the joint-surplus maximizing levels, whereas in ours the firm and the worker independently and non-cooperatively invest.
- Lazear's model has a richer structure on the second-period employment opportunity. In particular, a worker is employed by firm 1 in period 1 and, after investment in skills is made but before the second period begins, (i) the other firm, denoted j, appears as the worker's potential second-period employer, where λ_j is the realization of the random variable λ with density $f(\lambda)$, and (ii) the worker is laid off by firm 1 with an exogenous probability q. Given this, the model captures several important issues such as wage differences between stayers and leavers, and the relationship between wage loss and turnover. Our extension simplifies this part of the model by assuming that $q = 0$, λ_j is deterministic, and letting $j = 2$ where $\lambda_2 < \lambda_1$.

3. New implications of the skill-weights approach

By analyzing the model, we show how the firm and the worker's non-cooperative investment are related to the weights each firm puts on the skills. Although the skills are fully transferable between the firms, *investment* in each skill can be partially specific to a firm. We demonstrate the relationship between this firm-specificity of each firm's skill investment and under- or over-investment (relative to joint-surplus maximizing levels of investment) in skills. We then discuss the implications of our results for firms' training programs.

Let us first consider the cooperative equilibrium levels of investment by the firm and the worker, denoted respectively by $\left(\hat{a}_1, \hat{b}_1\right)$ and $\left(\hat{a}_w, \hat{b}_w\right)$, as a benchmark. Suppose, as in Lazear (2009), that the firm and the worker cooperatively choose their investment levels to maximize their joint surplus $\lambda_1(a_1 + a_w) + (1-\lambda_1)(b_1 + b_w) - \left(\frac{1}{2}a_1^2 + \frac{1}{2}b_1^2\right) - \left(\frac{1}{2}a_w^2 + \frac{1}{2}b_w^2\right)$. We find that $\left(\hat{a}_1, \hat{b}_1\right) = \left(\hat{a}_w, \hat{b}_w\right) = (\lambda_1, 1-\lambda_1)$.

We now find non-cooperative equilibrium levels of investment, denoted (a_1^*, b_1^*) and (a_w^*, b_w^*), by deriving Subgame Perfect Nash Equilibria (SPNE) in pure strategies of our model. At Stage 2, the worker stays with firm 1 if $y_1 \geq y_2$ and moves to firm 2 if $y_1 < y_2$, where the worker's second-period wage is $w_2 = \frac{y_1+y_2}{2}$ in both cases. At Stage 1, the worker chooses (a_w, b_w) to maximize his net benefit of the investment, denoted $\pi_W(\lambda_1, \lambda_2, a_1, a_w, b_1, b_w) \equiv w_2 - [C_A(a_w) + C_B(b_w)]$, taking (a_1, b_1) as given. Since $w_2 = \frac{1}{2}(y_1 + y_2)$, we have that

$$\pi_W(\lambda_1, \lambda_2, a_1, a_w, b_1, b_w) = \frac{1}{2}(\lambda_1 + \lambda_2)(a_1 + a_w) + \left[1 - \frac{1}{2}(\lambda_1 + \lambda_2)\right] \times (b_1 + b_w) - \frac{1}{2}a_w^2 - \frac{1}{2}b_w^2. \quad (1)$$

For any given (a_1, b_1), the worker chooses $a_w = \frac{1}{2}(\lambda_1 + \lambda_2) \equiv a_w^*$ and $b_w = 1 - \frac{1}{2}(\lambda_1 + \lambda_2) \equiv b_w^*$ in the equilibrium.

Firm 1's second-period profit, denoted $\pi_{F1}(\lambda_1, \lambda_2, a_1, a_w, b_1, b_w)$, is $y_1 - w_2 = \frac{1}{2}(y_1 - y_2)$ if $y_1 \geq y_2$ and 0 otherwise. We then have that

$$\begin{aligned}\pi_{F1}(\lambda_1, \lambda_2, a_1, a_w, b_1, b_w) &= max\left\{\frac{1}{2}(y_1 - y_2), 0\right\} - [C_A(a_1) + C_B(b_1)] \\ &= max\left\{\frac{1}{2}(\lambda_1 - \lambda_2)(a_1 + a_w - b_1 - b_w), 0\right\} \quad (2) \\ &\quad - \frac{1}{2}a_1^2 - \frac{1}{2}b_1^2.\end{aligned}$$

At Stage 1, anticipating that the worker chooses $(a_w, b_w) = (a_w^*, b_w^*)$, firm 1 chooses (a_1, b_1) to maximize $\pi_{F1}(\lambda_1, \lambda_2, a_1, a_w^*, b_1, b_w^*)$ in the equilibrium.

Proposition. The game has a unique SPNE outcome with the following properties.

(i) Suppose $\frac{5}{4}\lambda_1 + \frac{3}{4}\lambda_2 - 1 \geq 0$. Then $(a_1^*, b_1^*) = \left(\frac{1}{2}(\lambda_1 - \lambda_2), 0\right)$ and $(a_w^*, b_w^*) = \left(\frac{1}{2}(\lambda_1 + \lambda_2), 1 - \frac{1}{2}(\lambda_1 + \lambda_2)\right)$ hold, and in period 2 the worker stays with firm 1 in the equilibrium.

(ii) Suppose $\frac{5}{4}\lambda_1 + \frac{3}{4}\lambda_2 - 1 < 0$. Then $(a_1^*, b_1^*) = (0, 0)$ and $(a_w^*, b_w^*) = \left(\frac{1}{2}(\lambda_1 + \lambda_2), 1 - \frac{1}{2}(\lambda_1 + \lambda_2)\right)$ hold, and in period 2 the worker moves to firm 2 in the equilibrium.

[Proof]. As mentioned above, in the equilibrium the worker chooses $(a_w, b_w) = (a_w^*, b_w^*)$, where $a_w^* \equiv \frac{1}{2}(\lambda_1 + \lambda_2)$ and $b_w^* \equiv 1 - \frac{1}{2}(\lambda_1 + \lambda_2)$, and firm 1 chooses $(a_1, b_1) = (a_1^*, b_1^*)$, which maximizes the value of $\pi_{F1}(\lambda_1, \lambda_2, a_1, a_w^*, b_1, b_w^*)$ subject to $a_1 \geq 0$ and $b_1 \geq 0$. Let $\widetilde{\pi}_{F1}(\lambda_1, \lambda_2, a_1, a_w^*, b_1, b_w^*) \equiv \frac{1}{2}(\lambda_1 - \lambda_2)(a_1 + a_w^* - b_1 - b_w^*) - \frac{1}{2}a_1^2 - \frac{1}{2}b_1^2$. We find that $(a_1, b_1) = \left(\frac{1}{2}(\lambda_1 - \lambda_2), 0\right)$ maximizes the value of $\widetilde{\pi}_{F1}(\lambda_1, \lambda_2, a_1, a_w^*, b_1, b_w^*)$ subject to $a_1 \geq 0$ and $b_1 \geq 0$, where $\widetilde{\pi}_{F1}\left(\lambda_1, \lambda_2, \frac{1}{2}(\lambda_1 - \lambda_2), a_w^*, 0, b_w^*\right) = \frac{1}{2}(\lambda_1 - \lambda_2)\left(\frac{5}{4}\lambda_1 + \frac{3}{4}\lambda_2 - 1\right)$. This implies the result. *Q.E.D.*

In what follows, we assume $\frac{5}{4}\lambda_1 + \frac{3}{4}\lambda_2 - 1 \geq 0$ holds so that the worker stays with firm 1 in period 2 in the equilibrium.[5] An investment in skill A increases the worker's output more in firm 1 than in firm 2, and vice

[3] In Lazear's model, skill acquisition cost is $C(x_A, x_B)$. Our specification of additively separable costs is for analytical simplicity and does not affect the qualitative nature of the result.

[4] Alternatively, it can be assumed that firm 1 chooses (a_1, b_1) and then the worker chooses (a_w, b_w) or vice versa. The results are unaffected by these alternative setups.

[5] This condition holds, for example, when firms 1 and 2 are symmetric in the sense that $\lambda_1 = 1 - \lambda_2$ holds. Suppose $\frac{5}{4}\lambda_1 + \frac{3}{4}\lambda_2 - 1 < 0$. Then, anticipating that the worker will move to firm 2 in period 2, firm 1 makes no investments in skills A and B.