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ABSTRACT

Firm-Specific Human Capital: A Skill-Weights Approach*

One problem with the theory of firm-specific human capital is that it is difficult to generate convincing examples of investment that could generate the sometimes observed large and continuing effects on earnings. Another approach, called the "skill-weights" view, allows all skills to be general in that there are other firms that use the each of the skills. But firms use them in different combinations and with different weights attached to them. The skill-weights view not only has aesthetic appeal, but is consistent with the frequently observed large tenure effects. All of the implications of the traditional view are produced by this approach, and there are a number of other implications that distinguish the new view from the traditional one. The empirical evidence already contains some support for the skill-weights view.

JEL Classification: M5, J24

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Most professors of labor economics teach their students the difference between general and firm-specific human capital. Firm-specific human capital makes workers more productive in their current firm, but not elsewhere. General human capital augments productivity in the same way at multiple firms. But when searching for examples of firm-specific human capital, many of us fall back on the same cliched examples. "Knowing how to find the restrooms," "learning who does what at the firm and to whom to go to get something done," "learning to use equipment or methods that are completely idiosyncratic," are ones that come to mind. The problem is that it is difficult to generate convincing examples where the firm-specific component approaches the importance of the general component. If we think of our own jobs as academics, there is surely some value to knowing the specifics of the university at which we are employed, but does that capital come close to the amount of general economic knowledge that we have acquired on the job through seminars, reading and writing papers, and talking with colleagues? The answers is almost certainly no, and this is true for virtually every job that one considers. Yet the tenure coefficient is close to the same size as the experience coefficient in many empirical papers.[1]

Another view of firm-specific human capital is offered here that is based solely on general skills, but generates the findings observed in the literature on earnings functions. The approach is this. Suppose that there are a variety of skills used on each job and suppose that

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[1]See, for example, Topel (1991), who finds significant tenure effects even after accounting for endogeneity, and Neal (1995), table 4. Altonji and Shakotko (1987) argue that much of the earlier findings on tenure effects are biased upward as a result of heterogeneity. The first strong evidence of at least the possibility of firm-specific human was provided by Parsons (1972), which was inferred from a comparison of stayers' and leavers' earnings.

each of these skills is general in the sense that it is used at other firms as well. The difference, however, is that firms vary in their weighting of the different skills. A real-world example of which I have some personal knowledge may be helpful. A small Silicon Valley start-up provides enterprise software that does tax optimization. The typical managerial employee in this firm must know something about tax laws, something about economics, and something about software and Java programming. None of these skills, taken alone, is firm-specific. There are many other firms in the economy that make use of knowledge on taxes. Other firms use economic reasoning to produce their products. Java is a language used commonly throughout the Valley. But the combination of these skills, especially in the quantities used at the start-up in question, are unlikely to be replicated in many, if any, other firms. A manager who leaves the start-up will have a difficult time finding a firm that can make use of all the skills he acquired at the first firm. The second job might use some of the economics and some of the tax, but little of the programming expertise. Or it might use tax and programming, but little economics. In part, the loss in going to a new job depends on the thickness of the labor market and on search costs. When markets are very thick and search costs are low, a laid-off worker is more likely to find a job where skill demands match closely those of his previous assignment. When markets are thin and search costs are high, the worker might have to settle for a firm that makes little use of all the skills acquired at the prior firm, even though each of those skills is “general” in the sense that there are other employers who make use of the same skill. As a result, a separation, especially in thin markets and in high search cost occupations, results in a wage loss and yields a positive coefficient on tenure in wage regressions.

There are other stories that generate positive tenure coefficients, which have nothing to do with firm-specific human capital. Upward-sloping tenure-earnings profiles can provide incentives as in Lazear (1979, 1981). They may also reflect pure rent seeking activity if more senior workers are better at extracting rents than their junior counterparts. But there is a difference between these two rationales and traditional firm-specific human capital reasoning. In the case of firm-specific human capital, senior workers are underpaid relative to their productivities because of rent-splitting that is part of the equilibrium contract. Senior workers receive more than they could elsewhere, but less than they are worth to the firm. In the case of incentive profiles or rent-extraction, senior workers are paid more than their productivities. Other things equal, an exogenous shock (like a death) that induces a separation makes the firm worse off if the affected worker has firm-specific human capital. The same shock makes the firm better off if senior workers are overpaid.

Why bother with another story for specific human capital? The traditional view seems to have generated many predictions that are consistent with the data. The advantage of this new, "skill-weights" view of human capital is that it provides a more reasonable story and seems more consistent with high values of the tenure coefficients that are sometimes observed, as well as yielding all of the implications for earnings functions that are documented in the empirical human capital literature. Furthermore, a number of additional testable implications, some of which have already received the support of existing empirical work, come from this view, thereby distinguishing it from the traditional view of firm specific human capital. In short, this skill-weights view is likely to be closer to reality.

The Model

Let there be two skills, A and B, which the individual can acquire at cost C(A,B). Two skills and two periods are sufficient to derive all of the propositions. Think of workers making their investments during period 1 and receiving the payoff from work in period 2.

A worker with skill set (A,B) has potential earnings at firm i given by

$$(1) \qquad y_i = \lambda_i A + (1-\lambda_i) B$$

The λ_i reflects the fact that each firm i may weight the two skills differently from another firm j.[2]

The worker must decide on his human capital investment strategy. Define the initial firm, denoted firm1, as the firm at which the worker is employed during the first period. Before the second period begins, the worker learns whether he will continue at the initial firm or move to some other firm, which is given exogenously. Let the probability of remaining at the initial firm be p. The worker's investment problem is then to choose A and B, knowing that he may remain at the initial firm, but that there is some chance that he will have to move to another firm, which weights skills differently. The random variable λ has density $f(\lambda)$. So a worker at firm 1 chooses A and B so as to maximize

[2]Since the capital, or in this case weights, are firm specific, rents are shared. The sharing rule is subsumed in the definitions of A and B because they are not central to this analysis. It is possible to think of A as the part of skill A that the worker captures in earnings and similarly for skill B. As a result, we can abstract from the bargaining problem.

(2) $$\text{Net Earnings} = p[\lambda_1 A + (1-\lambda_1)B] + (1-p)\int_0^1 [\lambda A + (1-\lambda)B] f(\lambda) d\lambda - C(A,B)$$

The first-order conditions are

(3) $$p\lambda_1 + (1-p)\bar{\lambda} - C_A = 0$$

and

(4) $$p(1-\lambda_1) + (1-p)(1-\bar{\lambda}) - C_B = 0$$

Investment is a weighted average of the relevant skill-weights inside the firm and outside, where the weights depend on the probability of separation. The intuition is clear. If p=1 so that continuation in the initial firm is certain, then only the initial skill-weights matter and workers set

$$\lambda_1 - C_A = 0$$

and

$$(1-\lambda_1) - C_B = 0 \ .$$

At the other extreme when p=0, the current firm is irrelevant. Of course, the worker does not know where he will end up so he invests based on the expectation of λ, and investment solves

$$\bar{\lambda} - C_A = 0$$

and

$$(1-\bar{\lambda}) - C_A = 0 \ .$$

The Tenure Coefficient

The motivation given for this altered view of firm-specific human capital was that the tenure coefficient in earnings regressions seemed too high to be consistent with the stories about firm-specificity. The model presented above also yields a tenure coefficient, and it is instructive to examine it in light of the data.

Tenure coefficients in earnings regressions are identified in the cross-section by comparing those who leave the firm with those who stay at the firm. The difference between the earnings growth associated with a given amount of experience for those who stay and those who go loads on the tenure coefficient. The amount of wage growth that the leavers get loads on the experience coefficient. In the context of this model, wages are set to zero in period 1 and to

$$y_1 = \lambda_1 A^* + (1-\lambda_1) B^*$$

in period two for those who stay with their initial firm (where A* and B* are the optimal levels of A and B chosen). The leavers receive

$$y_2 = \lambda_2 A^* + (1-\lambda_2) B^*$$

where λ_2 is the skill-weight at the firm to which the worker moves. Recall that A* and B* are chosen based on λ_1 and the expected value of λ.

The tenure coefficient is that part of wage growth that is not common to both stayers and leavers, i.e.,

$$\Delta = \lambda_1 A^* + (1-\lambda_1) B^* - \lambda_2 A^* - (1-\lambda_2) B^*$$

or

$$\Delta = (\lambda_1 - \lambda_2)(A^* - B^*)$$

so the model predicts that one period's worth of tenure is then given by the expectation of Δ or

(5) Tenure effect= $E\{(\lambda_1 - \lambda_2)(A^* - B^*)\}$

The one-period experience effect is the part that is common to both, i.e., the returns that even leavers receive,

(6) Experience effect $= E\{\lambda_2 A^* + (1-\lambda_2) B^*\}$.

The sign of the tenure coefficient:

The loss associated with a move from the initial firm to a new firm is just the tenure effect, Δ . Is Δ always positive? Is there always a loss associated with moving from the first firm to another? The answer is usually, but not always.

The intuition is this. The worker must choose his investment strategy not knowing whether he will remain at the firm or not. Usually, p is sufficiently large so that the worker will invest in skills, banking primarily on continued employment at his initial firm. As a result, he then invests somewhat idiosyncratically, catering to the demands of the first job. When he loses that job and moves to another, he suffers a loss because he is unlikely to find a job that matches his skill set perfectly, given his idiosyncratic investment. But there are exceptions. If the probability that he is going to remain at his initial firm is very low, i.e., p is close to zero, the worker will adopt an investment strategy that is more consistent with $\overline{\lambda}$ than with λ_1. Under these circumstances, losing a job is good luck rather than bad. Because he invested in skills that match more closely with $\bar{\lambda}$, a job switch enables him to use his skills better, at least on average.

To see this, note from the first-order conditions (3) and (4) that as p goes to one, the worker ignores the rest of the market and invests only in skills that pertain to the initial firm. Any job loss under these circumstances puts him in a situation that can be no better than those at the initial firm and in general must be worse. Thus, the loss in (5) must be positive because A* and B* are optimal assuming only λ_1. As p goes to zero, the opposite applies. All investment is based on $\bar{\lambda}$ so the worker can do no better than going to the firm with the average λ. The initial firm cannot, in general, have $\lambda = \bar{\lambda}$ so the worker enjoys a gain when he moves.

Tenure effects and the probability of separation:

The intuition of the limiting cases p61 or p60 carries through more generally. It is possible to show that the expected value of the loss, Δ, increases with p.

To see this, note that the expectation of Δ can be written

$$E(\Delta) = \int_0^1 \int_0^1 (\lambda_1 - \lambda_2)(A^* - B^*) f(\lambda_1) f(\lambda_2) d\lambda_1 d\lambda_2$$

which is

(7) $$E(\Delta) = \int_0^1 (\lambda_1 - \bar{\lambda})(A^* - B^*) f(\lambda_1) d\lambda_1$$

because A* and B* do not depend on the realization of λ_2.

Differentiating with respect to p gives

$$\frac{\partial E(\Delta)}{\partial p} = \int_0^1 (\lambda_1 - \bar{\lambda})(\frac{\partial A^*}{\partial p} - \frac{\partial B^*}{\partial p}) f(\lambda_1) d\lambda_1 \quad .$$

Using the first-order conditions for A* and B* and substituting yields

$$\frac{\partial E(\Delta)}{\partial p} = \int_0^1 (\lambda_1 - \bar{\lambda})^2 (\frac{1}{C_{AA}} + \frac{1}{C_{BB}}) f(\lambda_1) d\lambda_1$$

which is positive.

Again, the result is quite intuitive. The expected loss rises with p because the individual adopts a more idiosyncratic investment pattern when he expects to stay with the firm. This is consistent with the original story of firm-specific human capital. Workers who do not expect to stay are unwilling to invest in firm-specific human capital. The same intuition applies here, but what is different is not that the skills are unique to the initial firm, but rather that their importance is greater at the initial firm than elsewhere. Thus, the size of the tenure coefficient should be negatively related to the amount of turnover in the occupation. The same implication follows from the traditional view of specific human capital.

Idiosyncratic firms and the tenure coefficient:

The tenure effect is larger for workers whose initial job is at a firm with relatively idiosyncratic weights. The reason is that the tenure effect is identified by comparing movers to stayers. Those who leave firms with unusual weighting patterns suffer larger wage loss for a given p.

To see this, differentiate (7) with respect to $\lambda_1 - \bar{\lambda}$ to obtain

(8) $$\frac{\partial E(\Delta)}{\partial(\lambda_1 - \bar{\lambda})} = \int_0^1 \{(\lambda_1 - \bar{\lambda})(\frac{\partial A^*}{\partial(\lambda_1 - \bar{\lambda})} - \frac{\partial B^*}{\partial(\lambda_1 - \bar{\lambda})}) + (A^* - B^*)\} f(\lambda_1) d\lambda_1$$

To show that the derivative in (8) is positive, first it is shown that it is positive for p=½. Then it is shown that the derivative is increasing in p so that it must be positive for all p>½.

First, define A to be the skill such that $\bar{\lambda} \geq$ ½ . Next, note from the f.o.c. in (3) and (4) that when p = ½ ,

$$C_A = \frac{\lambda_1 + \overline{\lambda}}{2}$$

and

$$C_B = \frac{(1-\lambda_1)+\left(1-\overline{\lambda}\right)}{2} \quad .$$

If A is idiosyncratic to the firm, then $\lambda_1 > \overline{\lambda} \geq \frac{1}{2}$, which implies that

$$\frac{\lambda_1+\overline{\lambda}}{2} > \frac{(1-\lambda_1)+\left(1-\overline{\lambda}\right)}{2} \; .$$

Given a symmetric cost function, by which C_A (A, B) = C_B (B, A), A* ≥ B*, this second term inside the integral in (8) is positive. The first term is

$$(\lambda_1 - \overline{\lambda})(\frac{p}{C_{AA}} + \frac{p}{C_{BB}}) > 0 \; .$$

Thus, when p = ½, the derivative in (8) is positive.

It is also true that the expression in (8) increases in p; so for p > ½, (8) is also positive. To see this, note that

$$\frac{\partial(A-B)}{\partial p} = \int_0^1 \{(\lambda_1 - \bar{\lambda})(\frac{1}{C_{AA}} + \frac{1}{C_{BB}}) + (\frac{\partial A}{\partial p} - \frac{\partial B}{\partial p})\} f(\lambda) d\lambda$$

$$= \int_0^1 \{(\lambda_1 - \bar{\lambda})(\frac{1}{C_{AA}} + \frac{1}{C_{BB}}) + (\frac{\lambda_1 - \bar{\lambda}}{C_{AA}} - \frac{(1-\lambda_1) - (1-\bar{\lambda})}{C_{BB}})\} f(\lambda) d\lambda$$

which is positive for $\lambda_1 > \bar{\lambda}$. This completes the proof.

The same analysis can be repeated in reverse so that when $\lambda_1 < \bar{\lambda}$, decreases in λ_1 result in larger losses from a random termination and therefore a larger tenure effect.

The intuition is clear. As a firm's requirements become more idiosyncratic, the worker's investment strategy, albeit tempered by the market, becomes less typical. A departure results in a larger loss because the worker has been induced to invest in skills that are less general. The effect is worsened as p goes to 1. When p is large, the worker is quite certain that he will remain with the first firm and invests even more idiosyncratically. When an unanticipated departure occurs, the loss is all the larger as a result.

Market Thickness

One implication of the skill-weights view of human capital that is less obvious under the prevailing view is that the tenure coefficient decreases with market thickness. As is made clear in this section, the definition of firm-specific human capital is actually endogenous. As market thickness increases, investments that would otherwise be viewed as firm specific become more general. Also, as markets become thicker, the individual undertakes investment strategies that are closer to the strategy that would prevail in the absence of any potential mobility, i.e., with p=1.

An increase in market thickness is modeled here as allowing more search. The model above assumes that if a separation occurs [which happens with probability (1-p)], the worker gets a new draw of λ. A thicker market is represented as one where when separation occurs, the worker gets two draws of λ and can select the job that best suits his prior investment strategy.

Since, as shown in the last section, the loss associated with a move increases in the difference between λ_1 and the new λ, it is clear that the worker will choose to work at the firm where λ is closer to λ_1. It also follows directly that the loss associated with the move must be smaller than it was with only one draw. (The most obvious proof of this proposition is that the worker could always ignore the second draw and be no worse off than when faced with only one λ).

Denote $\overline{\lambda}*$ as the expected value of λ on separation, given that the worker now has two draws and chooses the best of the two (in this case the closest to λ_1). The first-order conditions (3) and (4) now become

(3') $$p\lambda_1 + (1-p)\bar{\lambda}* - C_A = 0$$

and

(4') $$p(1-\lambda_1) + (1-p)(1-\bar{\lambda}*) - C_A = 0$$

Since it is necessarily the case that

$$\left|\lambda_1 - \bar{\lambda}*\right| \le \left|\lambda_1 - \bar{\lambda}\right|,$$

the convex combination shown in (3') and (4') must be closer to the pure investment strategy of

$$\lambda_1 - C_A = 0$$

and

$$(1-\lambda_1) - C_B = 0$$

that would prevail were the individual certain to stay at the initial firm. Thus, when markets are thick, the worker loses less on a move despite the fact that he engages in a more firm-specific investment pattern.

The reason is that when thickness of the market increases, the investment is not really so firm specific. Each skill taken by itself can always find a use in another firm, but as market thickness increases, the chances of finding a firm that uses skills in the same combination of those at the initial firm improve. It is in this sense that the definition of specific capital is endogenous. Tenure effects reflecting the idiosyncracy of skill weights that would be large when markets are thin become smaller when markets are thick.

Under the traditional notion of specific human capital, the thickness implication is less obvious, if present at all. When specific human capital takes the form of learning who does what in a firm or how things are done at a particular firm, it is unclear why having more firms in a market would make such knowledge more general.

Who Pays for Specific Training?

One of the "puzzles" in the literature has been that some forms of training seem general, yet firms seem to bear the cost of them.[3] Under the skill-weights view, it is natural that the firm would pay for at least some of the human capital that appears to be general. Take the example used for motivation, where a firm requires tax, economics and Java programming. Because a worker who leaves the firm will almost certainly fail to find another firm that needs the skills in the same proportions, and because this imposes a wage cost on mobile workers, the worker is unwilling to bear the full cost of training. The firm finances some learning about taxes, economics, and Java, even though each of these skills, taken separately, is completely general. A corollary is that as the skill mix becomes more idiosyncratic, workers are less likely to pay for the training even though each component is general.

Special Case

[3] This issue has attracted a good bit of attention in the literature, especially recently. Best known among recent contributions are Acemoglu and Pischke (1998) and Booth and Zoega (1999). Cappelli (2002) argues that this helps attract better workers to the firm.

The traditional view of firm-specific capital is merely a special, but unrealistic, case of this approach. Let each firm j have a factor x_j with a positive weight associated with it. Let all firms k…j have weight zero on that factor. Then, the traditional view of firm specificity is captured by this specification. For example, knowing the personalities at firm j have value at that firm, but nowhere else. But the view is unrealistic not because there are no factors that are completely unique to each firm, but because the unique factors are very unlikely to account for as much human capital as the non-unique factors. In order for the tenure coefficient to be as high as the experience coefficient, the weight on the idiosyncratic factor would have to be large enough to allow the contribution of the idiosyncratic component to equal that of all other common components combined. Thus, the large tenure coefficients can handle this special case, but are unlikely to be justified by it.

Firm-Specificity Increases with Tenure

One of the more important implications of the traditional view of firm-specific human capital is that the stock of firm-specific human capital increases with tenure on the job. In this section, it is shown that the skill-weights view of specific human capital provides the same implication.

To do this, let there be three periods instead of two. As before, an exogenous separation can occur at the end of period 1, which happens with probability $(1-p_1)$. Conditional on staying with the firm during period 2, an exogenous separation can also occur at the end of period 2, with probability $(1 - p_2)$. Now the worker faces a two-period problem. He must choose investment in period 1; then depending on whether he remains with the firm or leaves, choose investment in period 2.

The period 2 problem is identical to the one shown in first-order conditions (3) and (4), except that the relevant probability is p_2 . Conditional on having reached period 2, the investment problem is a one-period problem with first-order conditions[4]

$$(3'') \quad p_2\lambda_1 + (1-p_2)\bar{\lambda} - C_A = 0$$

and

$$(4'') \quad p_2(1-\lambda_1) + (1-p_2)(1-\bar{\lambda}) - C_B = 0$$

In period 1 the worker anticipates that he may leave the firm after one period or may remain for one or two more additional periods. The probability that he remains for two periods is p_1p_2 . The probability that he remains for the first but not the second is p_1 $(1-p_2)$. The probability that he leaves after the first period is $(1-p_1)$. The maximization problem in period 1

[4]There is a slight complication because investment is irreversible. So, for example, the worker might have invested in too much B, thinking that there was a good chance that he would move to another firm before period 2. After learning that he has been retained at least through the second period, he might prefer to have selected a lower level of B. Thus, in the conditions above, A and B should be interpreted as the maximum of A and B from (3") and (4") and A and B that come from the first-period maximization, below. The first-period problem will have already accounted for this irreversibility.

then yields first-order conditions

(3a) $$p_1 p_2 \lambda_1 + p_1(1-p_2)\frac{\lambda_1+\overline{\lambda}}{2} + (1-p_1)\overline{\lambda} - C_A = 0$$

and

(4a) $$p_1 p_2(1-\lambda_1) + p_1(1-p_2)\frac{(1-\lambda_1)+(1-\overline{\lambda})}{2} + (1-p_1)(1-\overline{\lambda}) - C_B = 0$$

Note that (3a) and (4a) are just weighted versions of the terms in (3) where the weights reflect the probabilities of each of the events. For example, a separation occurs at the end of period 2 with probability p_1 $(1\text{-}p_2)$ so the second term in (3a) is the optimal investment strategy given separation in period 2 times the probability of separation at the end of period 2.

Completely idiosyncratic investment occurs when p_1 and p_2 are equal to 1. Then, the worker chooses A so that $C_A = \lambda_1$ and B so that $C_B = (1\text{-}\lambda_1)$. Other skill weights are irrelevant. Now, in period 2 the worker chooses a hybrid of basing investment on λ_1 and basing it on $\overline{\lambda}$. The same is true in period 1.

In period 2 the weight attached to the firm's idiosyncratic production function is higher than in period 1 because $p_2 > p_1p_2$. (In the case where investment, say in B, from period 1 already exceeds the optimum for those who are retained, the condition becomes a weak inequality. Investment can never become less idiosyncratic.). As a result, investment in period 2 is more highly skewed toward the current firm's idiosyncratic weights, which implies that firm-specificity increases over the worker's tenure with the firm.

This provides two implications. The first is the standard one that specific human capital investment increases over time simply because surviving in the firm implies that another round of investment is appropriate. The second implication, not emphasized in the standard theory, is that investment becomes more idiosyncratic over time. Not only does the worker undertake additional investment, but the nature of this investment becomes more skewed to the needs of the current firm.

The Size of the Tenure Coefficient

Part of the justification for thinking about specific human capital in this somewhat different way is that the tenure coefficient is too large relative to the experience coefficient to be consistent with the stories behind the firm-specific effect. It is shown here that the model skill-weight interpretation of specific human capital can generate coefficients that are observed in the data.

To do this, simulations were done, where the λ for the initial firm and the firm that the worker lands in if terminated are drawn from either a uniform distribution on the [0, 1] interval or bimodal distribution. The bimodal allows λ = [0, 1] with equal probability. The results are contained in table 1.

Table 1
Results of Simulation
Effects of Tenure and Experience on Wages

p	p = .3		p = .6		p = .9	
Distribution	Uniform	Bimodal	Uniform	Bimodal	Uniform	Bimodal
Tenure	.049	.148	.099	.299	.150	.445
Experience	.499	.502	.500	.500	.500	.504
Ratio	.1	.3	.2	.6	.3	.9

There are a number of points that table 1 makes clear. First, it is possible to generate tenure coefficients that are nearly the same size as the experience coefficients. The bimodal case with p=.9 comes the closest. There, the experience effect is .504 and the tenure effect is .445, so that the tenure coefficient is about 90% as high as the experience coefficient. Second, the higher is p, the larger is the tenure coefficient relative to experience. This was proved above in the theory section and reflects the fact that the higher is p, the more idiosyncratic is investment. When the worker is almost certain that he will remain with the firm, he invests heavily in idiosyncratic skill patterns. An unexpected departure then brings large losses, which is reflected in high tenure coefficients. Third, the uniform distribution (where $0 \leq \lambda \leq 1$) yields lower tenure coefficients than the bimodal where $\lambda=0$ with probability .5 and $\lambda=1$ with probability .5. The intuition is this. When λ takes extreme values, it is certain to be very far away from $\bar{\lambda}$ which is .5 in both cases above. The binomial case guarantees the largest deviation between λ_1 and $\bar{\lambda}$, which means that the period 1 investment pattern generates bigger losses in the binomial case than in the uniform case. The main point, though, is that it is possible to generate coefficients on tenure and experience that have relative values that are observed in the real world.

Skill-Weights and Matching

The skill-weights interpretation is also consistent with the matching view of the labor market.[5] Think of a worker as being endowed with some vector of skills, (A_0,B_0) . Output is

$$\text{Output} = \lambda_1 A_0 + (1-\lambda_1)\, B_0 ,$$

and the derivative with respect to λ_1 is

$$\frac{\partial \text{Output}}{\partial \lambda_1} = A_0 - B_0$$

which is positive for $A_0 - B_0 > 0$. This means that matching consists of finding a firm with the highest λ_1 if $A_0 - B_0 > 0$ and finding a firm with the lowest λ_1 if $A_0 - B_0 < 0$.

The notion behind matching is that an individual has a set of skills that fit better in some firms than others. It is essentially equivalent to firm-specific human capital, except that the investment part is de-emphasized. In matching, there is no presumption that the worker learns the specific skills that make him a good match with a firm. Instead, in the matching story, the worker has an endowed set of skills, and those skills are better suited to some firms than to others. It is not that the skills are not useful anywhere else. A more reasonable interpretation of matching is that the value placed on skills that the individual possesses differs across firms.

[5]Jovanovic (1979a, b).

Thus, the skill-weight interpretation is not only consistent with matching but seems a natural view of it.

Empirically Testable Implications

The goal of theory is to provide implications that can be tested and verified or refuted. There are a number of implications of the skill-weights approach that go beyond those of the traditional view of firm specific human capital and some that can distinguish between the two.

1. Market Thickness: The implications of market thickness distinguish between the two theories. In the skill-weights approach, tenure effects should be smaller in thick markets than in thin markets. No such implication comes from the traditional view.

A market is thick when two conditions hold. First, the cost of searching for offers is low so the worker receives many offers for a given amount of search effort. Second, the density is such that the expected difference between the weight λ in the original firm and the weight λ in the newly offered job is small. Thus, a tight or concentrated distribution of λ results in lower tenure coefficients than a disperse distribution of λ. Empirical proxies of density and search costs might include regional population densities and industry and occupation concentration ratios.

2. Firm Size: When a worker leaves a large firm, tenure effects should be large. When a worker joins a large firm, tenure effects should be smaller. If large firms have lower turnover rates and can better cater to a worker's endowed skills, then workers from large firms are likely to be less diversified in their choice of skills than those from small firms. Thus, departures from

large firms should result in larger wage losses. Conversely, when a worker joins a large firm, there is a better chance that the worker will find a job that suits his pattern of prior investment because within the firm there is a larger range of specialization.[6] This is not an implication of the traditional view of firm-specific human capital.

3. Idiosyncratic Firms: The more idiosyncratic is a firm's skill-weights, the larger is the loss associated with a move. New and unusual technologies, even though general in the traditional sense, probably have more idiosyncratic weights. As a result, tenure effects should be larger in new and unusual industries. Newness is straightforward to measure, but it may be more difficult to obtain empirical analogues of "unusualness" in the sense that few firms attach significant weight to the skill required at the initial firm.

4. Payment for General Training: As already mentioned, firms will pay for a larger share of what would otherwise appear to be general training when the firm's particular weights on the skills are idiosyncratic. This implies that firms are more likely to pay for general training in industries and occupations where tenure effects are largest because those are the industries with the largest losses associated with moving from one firm to another.

5. Occupations: A very detailed definition of occupation might be thought to hold constant the skill-weights. That is, one way to define an occupation is such that all individuals in the occupation have identical skill weights. If so, then holding occupation constant in the wage regression should reduce the magnitude of the tenure effect. There is some evidence of this in Shaw (1984), table 4. Wage regressions that include occupational experience have somewhat

[6]Finding a job at a large firm contains an element of luck.

lower tenure coefficients than those without. More important, the occupational effect itself is about four times as large as the pure tenure effect. To the extent that occupation is a proxy for skill-weights -- and it surely cannot reflect firm-specific capital in the traditional sense -- then the fact that occupational experience is so important suggests that the skill-weights view has merit. Furthermore, if some occupations are defined better, i.e., more finely, than others, then those occupations that are defined best should have the lowest tenure coefficients. This can be thought of as an errors-in-variables problem. Poorly defined occupations generate variables that are more noisily measured. The coefficient on this variable is biased toward zero and that on others that proxy it are generally biased upward.[7]

6. Time-Dependent Tenure Effects: Because of the way that uncertainty gets resolved over time, the tenure effects should be largest at the time that a separation occurs and should die out over time. There is some evidence (Jacobson, LaLonde, and Sullivan, 1993), that supports this conclusion.

[7]See also Neal (1995) and Parent (2000), who find that industry and occupation effects eliminate the firm tenure effects.

Conclusion

The tenure effects found in the empirical literature on earnings functions are difficult to reconcile with the standard examples of firm-specific human capital. Often equal in size with the general experience effect, it is difficult to imagine that the firm-specific learning in the typical job is as great as the learning that transfers across firms. An alternative approach that is based on general human capital with firm-idiosyncratic weights provides all the implications of the traditional story, but has the virtue that it is more realistic. Furthermore, the skill-weights approach provides a number of additional implications, some of which have already been shown to be consistent with the data.

Like the traditional view, the skill-weights approach implies that workers who experience an exogenous change in job lose some earnings associated with their previous tenure. The amount of the loss grows as workers are with the firm for longer periods of time and tends to be greatest when separation probabilities are low, so that a worker is less likely to switch jobs. Further, the more idiosyncratic is the initial firm's technology, the larger is the loss associated with a job switch, even though workers hedge against this loss by adopting a more external-oriented investment strategy.

There are a number of additional implications that come from the skill-weights view. First, the size of the tenure coefficient varies with the thickness of the market. In markets where job offers are rare or where firms have very different skill weights, the tenure coefficient is larger than in those where offers are common and there are many firms with skill requirements that are close to one another.

The more idiosyncratic is the weighting of skills in which the worker is initially employed, the larger is the tenure coefficient. Thus, in new industries that use skills in uncommon combination (as economics, tax, and Java programming), the tenure coefficient should be relatively large.

The firm may bear some or even most of the cost of skills that look general. In the skill-weights version, no skills need be truly “firm-specific” in the sense of there being no other potentially competitive firm at which they have value. On the contrary, the skills appear to be general because in isolation, they are used at a number of firms in the market. But the weights differ by firm. If the skills are acquired in relatively idiosyncratic patterns, e.g., learning medicine and law in the same firm, the firm may bear a larger fraction of the cost of the skills that are most likely to be lost were the worker to be displaced.

Matching stories are a natural application of the skill-weights view. If workers possess some combination of general skills before arriving at a firm, a firm that weights most heavily those skills that the worker possesses in abundance is a good match for the worker.

The theory implies that workers who are displaced from large firms will have greater earnings losses than those who leave small firms. Conversely, those who join large firms will have smaller wage losses than those who join small firms.

Finally, the tenure effect should be reduced when industry and occupation effects are taken into account. There is ample evidence, found in a variety of data sets, that supports this implication.

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