Raiding and Signaling in the Academic Labor Market

by

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Abstract

Publications signal a professor's productivity and may lead to raids by other universities. A raided professor learns the value of non-wage benefits at a raiding university, and will quit only if benefits elsewhere are relatively high. The social value of these benefits suggests research may be efficient *even in the absence of a direct social value from research*. Other results are: in some cases, a school may preempt signaling by paying a higher wage, but it will only do so when signaling is inefficient; and it is inefficient for a university to commit to not match outside offers.

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1. Introduction.

In the last two decades, academicians in the U.S. have been criticized by state legislators, journalists, and foundations for allegedly emphasizing research over undergraduate education.[1] A series of books including *Profscam* (1988), *Imposters in the Temple* (1992), and *Inside American Education* (1993) was part of the chorus of criticism. Attempts by faculty members to justify research usually involve an emphasis on the creation of knowledge that results from research and publication. However, critics of research can counter by referring to the citation literature which suggests few articles are cited and even fewer have a significant effect on one's profession.[2]

The purpose of this paper is to consider whether time spent in research by faculty may enhance social welfare *even if there is no direct social value from research*. If, absent a direct social value from it, research may be efficient, the possibility of a direct social value for research would then enhance the efficiency justification for research.

An inefficiently large level of research may occur if research *has* direct social value. Siow (1995, 1998) notes a professor who publishes is more visible, and thus is more likely to receive an outside offer. Siow argues a professor’s private gain from research---the prospect of a higher salary---exceeds the social gain from research. Thus a professor will devote an inefficiently large amount of time to research.

However, there are (at least) two reasons why a professor may not spend too much time in research. First, suppose, as does Siow (1995, 1998), research has social value in that it enhances a professor’s knowledge. Then a university may not reward research enough to induce the socially optimal level. The reason is, the more visible a professor, the higher the wage the university must pay. A similar phenomenon was considered by Waldman (1984). He found firms might promote an inefficiently small

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[1] Nobel laureate Merton Miller cited a week-long series of articles in the Chicago Tribune suggesting the University of Illinois reduce spending on research (Miller, 1992). In North Carolina, the John Locke Foundation produced reports critical of research at the University of North Carolina (Sykes, 1992). A segment on *Sixty Minutes* (February 26, 1995) considered teaching and research at the University of Arizona.

[2] Laband (1986) examined articles cited from 1977 through 1982, which were published in the previous thirty years in forty economics journals. Only one tenth of one percent had two hundred or more citations in this period.

number of individuals because promotion provides information to other firms regarding the productivity of those promoted.[3]

Second, suppose research does not enhance a professor's knowledge, so there is no direct social value from research. If more able individuals are also more capable in research, publications may serve as a signal of a professor's productivity,[4] and may lead to raids by other universities. A professor who receives an outside offer learns something about employment at a raiding university that would be unknown without an offer. A raided professor will visit the raider's campus; learn about the faculty in the raiding department; and may negotiate teaching loads and schedules, and research support. These job benefits (other than salary) will be referred to as *job satisfaction*.

The social benefit from job satisfaction results because a raided professor who learns job satisfaction at the raider's university has an *option value*. A professor who learns (after a raid) satisfaction is relatively high elsewhere may quit, even with a counteroffer from the professor's current employer. *Option value* equals the probability one quits if raided multiplied by the conditional expected job satisfaction of a quitter. Since option value is a social benefit from being raided, and a raid occurs only if the more able signal their ability via publications, it is possible option value exceeds the cost of signaling, in which case signaling is efficient.

Option value in the labor market was analyzed by Lazear (1998). He demonstrated a firm might prefer to hire risky workers if the firm can truncate its losses by firing workers who are found to have relatively low productivity. Herein, option value is for workers (professors) who can avoid low draws of job satisfaction elsewhere by not quitting. Herein, I ignore the productivity-enhancing effects of research discussed above, and thus I preclude possible underinvestment in research because a university wants to "hide" the ability of its more productive professors from other schools. Although a good argument can be made for the importance of research in enhancing a professor's human capital, by focusing only on option

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[3] Golan (2005) shows the matching of outside offers by a raided firm can induce efficient job assignment. Ishida (2004) demonstrates signaling may induce more promotions, thereby reducing the welfare loss from inefficient job assignment.

[4] The possibility publications may signal the productivity of professors was considered by Paul and Rubin (1984), Forbes and Paul (1991), and Siow (1997).

value as a social benefit of research, the analysis tends to understate the possibility research is efficient. The outline of the rest of this paper is as follows. In Section 2, the analysis herein is contrasted with that in related papers. In Section 3, a model of signaling and raiding is developed. In Section 4, I consider whether a university can profitably preempt raids by paying a higher wage. In Section 5, other extensions to the basic model are considered. Concluding remarks are contained in Section 6.

2. Comparisons with related work

Observations of raids in academia suggest the following occurs.

- Those who publish the most are the ones who may be raided.
- Not all raided individuals quit.
- Counteroffers often occur, but do not necessarily match outside offers.
- Professors who are raided subsequently learn something about aspects of employment at raiding schools, what is called *job satisfaction* herein.
- One’s current employer may know more about one’s productivity than a raider does.

Lazear (1986) considered raids with offer matching in a model in which there is match-specific productivity analogous to job satisfaction herein. In his model, the employer and the raider have some exogenous probability of learning an individual’s productivity. In most of Lazear’s analysis, he assumed the raider and the employer have the same probability of being informed regarding worker productivity. One result is the best workers are raided. Herein, it is *assumed* those believed to be the most productive are raided.

Siow (1998) argued faculty slots are scarce, and used this observation to explain up-or-out rules in academia. Accordingly, scarce slots suggest universities desire the best workers they can attract, so raids are directed towards high productivity individuals. In contrast to Lazear’s model, herein it is assumed one's employer has more knowledge than does a raider regarding an individual's productivity. Also, I allow individuals to expend resources to signal their productivity. This occurs via publications. Lazear did not consider the possibility of signaling by those raided, and thus did not examine the efficiency implications of raids.

Banerjee and Gaston (2004) consider a model of signaling and job turnover. In their model, (1) a noisy, costless, and exogenous signal of productivity occurs; (2) the employer knows more about a worker's productivity than does a raider; (3) raiders suffer at least a partial winner's curse; (4) counteroffers are costly; (5) an employer knows a worker's cost of job switching; (6) the less productive workers are more likely to turnover; and (7) equilibria exist in which there is no turnover. In the model herein, signaling is costly, and its level is determined by what is necessary to deter the less productive from mimicking the more productive, as in Spence (1974); the employer knows more about a worker's productivity than does a raider; no winner's curse results because it is anticipated by raiders; counteroffers are costless; an employer does not know a worker's cost of *and* benefit from job switching, the net amount of which is called job satisfaction; and the more productive workers are the only individuals who quit.[5] Other than assumption (2) and result (7), the model herein differs in the seven assumptions and results listed above from Banerjee and Gaston. Also result (6) does not seem consistent with the academic labor market in which good workers are raided.

Postel-Vinay and Robin (2004) argue workers may search too much when search is costly to firms. They consider when firms may commit to matching offers *or* to never matching offers. Herein, it is assumed counteroffers are not costly to firms, other than, of course, the private cost of paying a higher wage. In Section 5, we consider the effects of a school's commitment to not match outside offers.

Barron, Berger, and Black (2004) assume firms can not credibly commit to not match *or* to match outside offers. As opposed to Postel-Vinay and Robin, Barron *et al*. assume private information on reservation values. Both papers focus on the optimality of search intensity of workers. Also, in Barron *et*

[5] In the model developed in the next section, if low productivity individuals *were* to mimic the level of publications of those with high productivity, then low productivity individuals would have a higher probability of quitting than those with high productivity. In the signaling equilibrium, low productivity individuals do not turn over.

al., non-wage benefits at one's employer are known only by the employee. Herein, the counterpart of search intensity is signaling via publications. A university's choice of the wage can affect whether signaling will occur (Section 4). Also, the value of non-wage benefits or job satisfaction at a raiding school is assumed unknown to all until a professor is raided. Satisfaction at one's current employer is assumed known to all.

Thus, although there are some similarities between the model herein and those in the papers discussed in this section, there are also significant differences, particularly in the focus herein on costly signaling of productivity, and on the efficiency implications of signaling and turnover.

Regarding the five bulleted items at the beginning of this section and the model herein: the first, fourth, and fifth are assumptions, and the second and third are results of the model. Thus, the model seems to describe the academic labor market reasonably well.

3. The model

Essentials

Consider a world in which a university, U, employs professors who are of two possible types: high productivity, H, and low productivity, L, with productivity denoted by x_H and x_L. Research has no effect on productivity. U knows a professor's type, but other universities do not have this information. For reasons given in the next sub-section, professors who do not signal via publications are all paid a wage equal to x_L. Let job satisfaction at U equal zero. Satisfaction elsewhere, which is learned only after a raid, is S.[6] For want of a better objective function, it is assumed U maximizes profit. The timeline of the model is as follows:

i) U offers the same wage to all professors.

[6] One can think of S as job satisfaction elsewhere minus moving cost. A professor may know moving cost, but does not know the value of job satisfaction without being raided.

ii) Hs may signal via the number of publications produced, and attract outside offers. The possibility not all who signal receive an outside offer is considered in Section 5.

iii) Two or more identical outside universities bid in Bertrand fashion for a professor who signals. The professor randomly chooses to consider one offer. These outside firms are referred to as the market, M. Competition between raiders (M) raises the outside offer to x_H for those who signal (since M believes---correctly in a signaling equilibrium---anyone who publishes a certain amount is an H).

iv) U chooses a counteroffer, W_C.

v) Hs learn job satisfaction in the market, S, and decide whether to quit or accept the counteroffer.

Note, when the terms "outside offer" and "counteroffer" are used herein, they refer to the monetary compensation for professors.

The wage for those who do not signal

Those who do not signal are paid x_L. Consider why this will be true. One argument is, if M does not know an individual professor's productivity, but knows the percentage of Hs at U will tend to equal λ, then M might offer anyone at U a wage equal to the expected productivity of these professors, E(x), with $E(x) = \lambda x_H + (1-\lambda)x_L$. However, U would not make counteroffers to Ls, so M would suffer a complete winner's curse, attracting only Ls. Thus M would only offer x_L to a professor at U.

The winner's curse argument in the preceding paragraph is not sufficient to ensure those who do not signal will be paid x_L. With job satisfaction elsewhere equal to S, not all Hs would be retained at U by a counteroffer, nor would all of the Ls leave. Thus, the complete winner's curse would not occur, and M might break even with a raid, provided its wage offer adjusted to reflect the actual combination of Ls and Hs it would expect to attract. However, one still would find only x_L offered by M to professors at U if: a) faculty slots are scarce so M will not make an offer unless it believes the individual is an H; or b) what has been called job satisfaction herein, S, represents non-wage aspects of employment at M that are costly for M to provide, and again, because of the scarcity of faculty slots, S will only be offered to those believed to be an H.

Possibilities a) and b) are observationally equivalent provided with b) the cost of S is fixed. If there were a positive marginal cost of S, then M would offer a wage equal to x_H minus the cost of S per professor. This would affect quit decisions, the conditional expected job satisfaction of quitters, and the social cost of signaling. For now, assume S is costless or involves a fixed cost. In Section 5, the case of a positive marginal cost for S is considered. Note, a fixed cost for S might occur if the non-wage benefit were a laboratory wherein sufficient space existed so another professor could use the laboratory at little additional cost.

The quit decision

A professor who has signaled, attracted an outside offer, and learned S may receive a counteroffer and then must decide whether to quit. As is the case in any signaling equilibrium (Spence, 1974), an L must not want to produce the same number of publications,[7] q, as an H. Thus, in order to ensure an L will not mimic an H, one must consider the signaling and quit decisions of an L. An L who signaled (and was believed to be an H) would received an outside offer of x_H. Since U knows the productivity of its professors, U would not make a counteroffer, and an L who did not quit would be paid x_L. With S equal to job satisfaction at a raiding school, let E(S) equal zero, with S distributed on $[-\Delta, \Delta]$ with a density of $\frac{1}{2\Delta}$. A uniform distribution is assumed in order to obtain an explicit solution for the counteroffer for Hs, W_C. Let $m \equiv x_H - x_L$.

Assumption One. $\frac{\Delta}{2} < m < \Delta$.

[7] Clearly q can be thought of as some observable measure of both quantity and quality of publications, where the latter could be measured by citations. For brevity, q will be referred to as the number of publications.

As demonstrated below, if $m \geq \Delta$, an L who mimicked an H would always quit when raided. In this case, the worst possible draw of job satisfaction, $-\Delta$, is not large enough to offset the wage gain, m, from quitting. The assumption $m < \Delta$ is made to allow for the possibility an L might not quit if raided. It will be shown the results herein do not depend on this assumption. If $m < \frac{\Delta}{2}$, the probability a raided H will quit is low enough so the counteroffer, W_C, would be less than x_L. Since a counteroffer lower than one's current wage is not usually (ever?) observed, for the sake of realism, it is assumed $m > \frac{\Delta}{2}$.

Now an L who mimicked an H by publishing and was offered x_H would quit if $x_H + S \geq x_L$, or if $S \geq -m$. Let p_L = the probability an L who signaled and was raided would quit. We have:

$$p_L = 1 - \frac{1}{2\Delta}\int_{-\Delta}^{-m} ds = \frac{\Delta + m}{2\Delta}, \tag{1}$$

with $p_L < 1$ by Assumption One. An L who quit would have conditional expected job satisfaction, $\overline{S}_L$, equal to:

$$\overline{S}_L = \frac{\frac{1}{2\Delta}\int_{-m}^{\Delta} S\,dS}{\frac{1}{2\Delta}\int_{-m}^{\Delta} dS} = \frac{\Delta - m}{2}. \tag{2}$$

Similarly, one can derive the quit probability, p_H, and the conditional expected job satisfaction, $\overline{S}_H$, for an H, the only difference being an H who is raided is offered W_C instead of x_L.

$$p_H = \frac{\Delta + x_H - w_C}{2\Delta}, \tag{3}$$

$$\bar{S}_H = \frac{\Delta + w_C - x_H}{2}, \tag{4}$$

Using eqs.(1) - (4), it is clear $p_L > p_H$ and $\bar{S}_H > \bar{S}_L$. Also, as shown in the Appendix, *for any continuous distribution of S*, $p_H \bar{S}_H > p_L \bar{S}_L$. Now $p_H \bar{S}_H$ is the expected gain in job satisfaction for an H who quits, and $p_L \bar{S}_L$ is the same thing for an L. For brevity, this shall be referred to as the *option value* of signaling and quitting. A higher option value for Hs than for Ls is important for the results derived below.

The optimal counteroffer

An L who mimicked an H in publications and was raided would not receive a counteroffer, and would only receive the original wage, x_L. An H would receive a counteroffer, W_C, that maximizes the expected profit for U:

$$\max_{W_C} \{(x_H - W_C)(1 - p_H)\},$$

which yields:

$$W_C = x_H - \frac{\Delta}{2}. \tag{5}$$

From eq.(5), it is clear $W_C > x_L$ only if $m > \frac{\Delta}{2}$, as discussed above. Using eqs.(3) - (5), $p_H = ¾$, and $\bar{S}_H = \frac{\Delta}{4}$, so option value for an H equals $\frac{3\Delta}{16}$. Thus, with a uniform distribution for S, a raided H quits 75% of the time. Without any data on raids of professors, one can not say whether this result is consistent with actual behavior.

Signaling via publications

A simple production process is assumed for publications. With the input of effort, y, an L can produce publications, q, with q = y. For an H, q = by, with $b \geq 1$. Let the effort cost of publishing equal y^2 for either an H or an L. Thus, in order to produce q publications, an L has cost of q^2, and an H has cost of $\frac{q^2}{b^2}$. In the typical signaling model, b would have to exceed one in order for an L not to mimic an H.

Proposition One. Ignoring for now the possibility of a higher wage preempting signaling, signaling will always occur, even if b = 1.

Proof. Let the net payoff from signaling for an L and an H be denoted I_L and I_H respectively. An L who signaled (mimicked an H in publications) would quit with a probability of p_L and have a wage plus conditional expected satisfaction of $x_H + \overline{S}_L$. With a probability of $1\text{-}p_L$, an L would remain at U and be paid x_L. The cost of signaling for an L is q^2. Using eqs.(1) and (2):

$$I_L = \frac{(m+\Delta)^2}{4\Delta} + x_L - q^2. \tag{6}$$

An H who signaled would quit with a probability of ¾ , and would then receive a wage of x_H and conditional expected satisfaction of $\frac{\Delta}{4}$. An H who did not quit would be paid $W_C = x_H - \frac{\Delta}{2}$. Signaling cost for an H is $\frac{q^2}{b^2}$. Thus:

$$I_H = x_H + \frac{\Delta}{16} - \frac{q^2}{b^2}. \tag{7}$$

Suppose b = 1. Then $I_H > I_L$ if:

$$m + \frac{\Delta}{16} > \frac{(m+\Delta)^2}{4\Delta}\text{, or}$$

$$-4m^2 + 8\Delta m - 3\Delta^2 > 0. \qquad (8)$$

If $m \rightarrow \frac{\Delta}{2}$, the LHS of ineq.(8) $\rightarrow$ 0. Also, $\frac{\partial LHS}{\partial m} = 8(\Delta\text{-}m) > 0$ by Assumption One. Thus, for $m > \frac{\Delta}{2}$, $I_H > I_L$ when b = 1. A larger b makes I_H even larger. As noted above, the assumption $p_L < 1$ does not change anything of consequence. Suppose $p_L = 1$. Now an L who signals always quits, so $\overline{S}_L = 0$ (the mean of S), and $I_L = x_H - q^2$, which is clearly less than I_H for $b \geq 1$. To complete the proof, note $I_L > x_L$ for a small enough (less than $\frac{(m+\Delta)^2}{4\Delta}$) effort expenditure by an L on publications, with x_L the payoff to one who does not signal. Thus, assuming an indifferent L will not signal, with q^2 an L's cost of publishing, an L would prefer not to mimic an H if $q \geq \frac{m+\Delta}{2\Delta^{1/2}}$. The Riley outcome (Riley, 1979) is the least cost level of the signal, call it q_R, that yields a separating equilibrium. Then:

$$q_R = \frac{m+\Delta}{2\Delta^{1/2}}. \qquad (9)$$

With $q = q_R$, since q_R just makes an L indifferent to signaling, clearly $I_H > \frac{q_R^2}{b^2}$ for $b \geq 1$, and signaling occurs. ■

Why is $I_L < I_H$, even if b = 1, so Hs and Ls have the same cost of signaling? An apparent explanation is an H has a higher return than an L from signaling because an H who learns S will be relatively low and does not quit is paid more than an L who does not quit, W_C versus x_L. However, as was shown, even if an L would *always* quit, $I_L < I_H$. Thus, the fact an H who does not quit earns more than an L who does the same is not *directly* responsible for $I_H > I_L$.

The reason I_H exceeds I_L *is indirectly* related to W_C exceeding x_L. An H has a higher cutoff for the value of S below which one would not quit. For an H, this value is $W_C - x_H$, and for an L, the value is $-m = x_L - x_H$. This is the reason why $\overline{S}_H > \overline{S}_L$. With $p_H \overline{S}_H > p_L \overline{S}_L$ (see the Appendix), option value is what drives the result $I_H > I_L$, even if b = 1.

Note: Proposition One can not be proven for a general distribution of S (see the Appendix).

Proposition Two. Signaling may be efficient, but is inefficient unless b is sufficiently larger than one.

Proof. The cost of signaling for an H is $\frac{q_R^2}{b^2}$. The social gain from an H signaling is the option value of satisfaction, $p_H \overline{S}_H = \frac{3\Delta}{16}$. Using eq.(9), signaling is efficient if:

$$3b^2\Delta^2 > 4(\Delta+m)^2 \quad (10)$$

The larger is b, the lower the cost of signaling for an H. A larger m implies a larger I_L (and I_H); thus q_R increases and signaling cost rises. Signaling is most likely to be efficient the smaller is m. If $m \to \frac{\Delta}{2}$, signaling is efficient only if $b > \sqrt{3} \approx 1.73$. If $m \to \Delta$, signaling is efficient only if $b > \sqrt{\frac{16}{3}} \approx 2.31$. ■

Thus signaling *may* be efficient, but, with a uniform distribution of job satisfaction, efficient signaling requires a lower cost for publishing for high productivity individuals than for those with low productivity, and is more likely to be efficient when the productivity difference between Hs and Ls, m, is smaller.

Intuitively, signaling may be efficient for the following reason. Part of the private return to signaling is also a social return: the option value of job satisfaction. Although an L who signaled would have a net private gain just equal to cost, the net gain for an H is higher (because option value is higher), and, if b exceeds one, an H has a lower cost than an L from signaling. Thus, even though the private gain from signaling exceeds the social gain, an H has a private gain that exceeds the cost, and, for b sufficiently large, the social gain may exceed the cost.

4. Can signaling via publications be preempted?

Proposition One suggests signaling always occurs in this model (with S distributed uniformly). However, one must consider the possibility U can preempt signaling by paying all a wage that exceeds x_L.[8]

Proposition Three. There are some cases when signaling may (profitably) be preempted, but only when signaling is inefficient.

Proof. Normalize the number of professors (pre-raids) at one, with λ the fraction of Hs at U (pre-raids). Since U earns zero profit on Ls, its expected profit if raided, π_{raid}, is then:

$$\pi_{raid} = \lambda(1\text{-}p_H)(x_H\text{-}W_C) = \frac{\lambda\Delta}{8}, \tag{11}$$

using eq.(5) and the fact $p_H = 3/4$. If U can pay $x_L + \delta$ to each professor and deter signaling, with $\delta > 0$, its profit, $\pi_{preempt}$, is:

$$\pi_{preempt} = \lambda x_H + (1\text{-}\lambda)x_L - x_L - \delta = \lambda m - \delta. \tag{12}$$

U prefers preemption to being raided if $\delta < \lambda\left(m - \frac{\Delta}{8}\right)$. Thus the most U can afford to pay to preempt raids is $x_L + \lambda\left(m - \frac{\Delta}{8}\right) \equiv W_P$. The question is whether an H would prefer to signal, or to receive

[8] Again, if U paid a higher wage only to Hs, this would indicate to M which professors were Hs.

W_P and not signal. Since U can anticipate what an H would do, if U believes W_P will *not* deter signaling, then U will not offer this wage. Thus, *with* signaling, as in the previous section, Ls do not publish and are paid x_L; Hs publish the amount $q = q_R$ (eq.(9)), are raided, and receive a counteroffer $W_C = x_H - \frac{\Delta}{2}$.

Using W_P and eqs.(7) and (9), an H prefers signaling to the preemptive wage offer if:

$$(1-\lambda)m - \frac{(m+\Delta)^2}{4\Delta b^2} - \frac{\Delta}{8}\left(\frac{1}{2}+\lambda\right) > 0. \tag{13}$$

Clearly, the lower is signaling cost (the larger is b), the more likely an H would prefer signaling to preemption. From ineq.(10), we can find the minimum b for which signaling is efficient; call this b*. From ineq.(13), we have the minimum b for which Hs prefer signaling to preemption; call this b**. We have:

$$b^* = \frac{2(\Delta + m)}{\Delta\sqrt{3}}, \tag{14}$$

$$b^{**} = \frac{\Delta + m}{2\Delta^{1/2}\left[(1-\lambda)m + \frac{\Delta}{8}\left(\frac{1}{2}+\lambda\right)\right]^{1/2}}. \tag{15}$$

It is easy to show b** is positively related to λ, and $b^{**}|_{\lambda=1} = b^*$. Thus, for $\lambda < 1$, $b^{**} < b^*$, and signaling is never preempted when it would be efficient. ■

Table One illustrates some values for b* and b**. Preemptive wage offers reduce the likelihood inefficient signaling will occur. From Table One, as the percentage of Hs in the population of professors rises (λ is high), W_P is then relatively high, and the likelihood inefficient signaling occurs is reduced considerably. The results reported in Table One suggest schools with a large percentage of high productivity professors are less likely to have faculty who publish. If the model included a direct value by universities for publications *per se*, one might expect to find, the larger the percentage of highly productive professors at a university, the more publications per faculty member.

Table One			
λ	m	b**	b*
0.1	.5Δ	1.04	1.73
0.2	.5Δ	1.07	1.73
0.9	.5Δ	1.58	1.73
1.0	.5Δ	1.73	1.73
0.1	.75Δ	1.01	2.02
0.2	.75Δ	1.06	2.02
0.9	.75Δ	1.75	2.02
1.0	.75Δ	2.02	2.02
0.1	Δ	1.01	2.31
0.2	Δ	1.06	2.31
0.9	Δ	1.91	2.31
1.0	Δ	2.31	2.31

Section 5. Other extensions

Commitment to not match outside offers

As noted earlier, Postel-Vinay and Robin (2004) consider the possibility U can commit to not match outside offers. Suppose there is some (un-modeled) long run gain to U if it does not match outside offers. In this case, an H who signaled, was raided, and stayed at U would only receive a wage equal to x_L. In this case, if b =1, $I_H = I_L$. Thus, for signaling to occur, b must exceed one.

Proposition Four. A policy of not matching outside offers makes signaling less likely to be efficient.

Proof. The level of the signal required to deter Ls from mimicking Hs is the same as before (eq.(9)), but now $p_H = p_L$ and $\overline{S}_H = \overline{S}_L$ (eqs.(1) and (2) respectively). Signaling is efficient only if:

$$b > \sqrt{\frac{\Delta + m}{\Delta - m}} \equiv b^{***} . \qquad (16)$$

With U paying W_C to Hs who signaled and were raided, signaling was found to be efficient only if $b > b^*$ (eq.(14)). Now $b^{***} > b^*$ if $4m^2 > \Delta^2$, which is true if $m > \frac{\Delta}{2}$. ■

In models of on-the-job search, it may be efficient for a firm to commit to not match outside offers because otherwise search may be socially excessive. However, with signaling of productivity in order to obtain an outside offer, since firms would never match outside offers for low productivity workers, the latter's return to signaling is unaffected by a no-match policy. Thus the level of the signal required to deter low productivity individuals from mimicking those with high productivity is also unchanged. Provided b > 1, Hs still prefer signaling to receiving a wage equal to x_L. All that occurs with a policy of not matching counteroffers is Hs are more likely to quit, so their option value from job satisfaction is reduced. The social gain from signaling is reduced, and a lower cost of signaling (larger b) is required in order for signaling to be efficient.

Not all who signal are raided

The scarce slots argument (Siow, 1998) suggests there may not be enough open faculty positions at raiding schools for all who signal. Suppose only the fraction ρ of those who signal are raided. The quit decisions of Ls and Hs are unaffected, but the net payoff from signaling is lowered for both. Using the analysis in Section 3, but when only ρ of those who signal are raided, we have:

$$I_H = \rho\left(m + \frac{\Delta}{16}\right) + x_L - \frac{q^2}{b^2}, \qquad (17)$$

$$I_L = \frac{\rho(m+\Delta)^2}{4\Delta} + x_L - q^2. \qquad (18)$$

Proposition Five. The condition for signaling to be efficient is independent of the fraction of those who signal who are raided.

Proof. For b =1, the condition for $I_H > I_L$ is exactly the same as before (ineq.(8)). The expected social gain from signaling is what it was before, except it now occurs for only ρ of Hs. Thus the social gain is $\frac{3\rho\Delta}{16}$. However, the minimum level of q that deters Ls from signaling is found where $I_L = x_L$, which yields the Riley outcome: $q_R = \frac{\rho^{1/2}(m+\Delta)}{2\Delta^{1/2}}$. Since an H's signaling cost is $\frac{q_R^2}{b^2} = \frac{\rho(m+\Delta)^2}{4b^2\Delta}$, the social cost of and benefit from signaling derived in Section 3 have both been multiplied by ρ. Thus, the condition for efficient signaling is the same as before and is independent of ρ. ■

The only thing different when not all who signal are raided is the net social gain or loss from signaling; it is ρ times what it was before.

Job satisfaction is costly

As discussed in Section 3, one interpretation of satisfaction, S, is it represents some non-wage benefits---teaching load, research assistants, etc.---that are costly for a university to provide. Suppose it costs a raider "C" per professor to provide S. The analysis is similar to that in Section 3, except now a raider offers a wage of x_H - C. In order for $I_H > I_L$ when b = 1:

$$-4m^2 + 8\Delta m - 3\Delta^2 + C(C-2\Delta) > 0. \tag{19}$$

If $C \geq \Delta$, non-wage benefits would not be offered: the cost of providing S would at least equal the maximum value of S. If $C < \Delta$, the fourth term on the LHS of ineq.(19) is negative, and the LHS of ineq.(19) is less than the LHS of ineq.(8)---the same condition but when C = 0. It was demonstrated above ineq.(8) holds for $m > \frac{\Delta}{2}$, but ineq.(19) will not hold for $m \approx \frac{\Delta}{2}$, so there is no guarantee signaling will occur if b = 1. Also, in addition to the cost of signaling, there is now the cost C per raided worker. Thus, given m, it is less likely signaling is efficient.

Matching counteroffers when turnover is costly

In the model developed in Section 3, a raided university, U, will never match an outside offer.[9] Since anecdotal evidence suggests such offers are matched some times, and, in isolated instances, are more than matched, the basic model is altered in order to introduce the possibility of counteroffers that equal or exceed x_H. Suppose when an H quits there is a cost to U from this turnover of T. Such a cost may be due to the necessity of finding someone to teach the field courses taught by the departing professor, shifting burdens of supervising doctoral dissertations, etc. Also, because of various subsidies available, suppose the university is not constrained to have non-negative profit. Now U's expected profit equals $(x_H-W_C)(1-p_H) - p_H T$. Using eq.(3) and the new profit function, the optimal W_C is:

$$W_C = x_H + \frac{T - \Delta}{2}. \tag{20}$$

[9] The model herein suggests a profit-maximizing university/firm chooses to balance the probability one quits with profit if one stays. This results (eq.(5)) in a counteroffer less than the value of the individual. Black and Lowenstein (1991) have a similar result when a firm makes a wage offer knowing a worker may quit.

Using eqs.(2), (3), and (20):

$$p_H = \max\left(\frac{1}{4}\left[3 - \frac{T}{\Delta}\right],\ 0\right), \qquad (21)$$

$$\overline{S}_H = \frac{T + \Delta}{4}, \qquad (22)$$

$$p_H \overline{S}_H = \frac{1}{16\Delta}(3\Delta - T)(T + \Delta). \qquad (23)$$

Assume $T < 3\Delta$ so $p_H > 0$. Note, using eq.(23), if $T < 2\Delta$, option value is higher with $T > 0$ than with $T = 0$. Option value is maximized when $T = \Delta$. At that point, $W_C = x_H$ and $p_H = ½$. Only if $T \geq \Delta$ would $W_C \geq x_H$; profit would then clearly be negative. Not surprisingly, the higher is T, the higher is W_C and the lower is p_H. Thus, if a raided school incurs a cost when a professor leaves, and may survive with negative profit, matching of or exceeding outside offers may occur if turnover is sufficiently costly.

Section 6. Conclusion

In the model herein, a professor who signals productivity via publishing may receive an outside offer, and thereby learns job satisfaction at a raiding university, an indirect social benefit of signaling. Such signaling may be efficient. When it is not efficient, signaling may be preempted by a higher wage from the employing university. It was also shown commitment to not match outside offers lowers welfare by reducing the expected gain in job satisfaction from those who quit when raided. With option value equal to the probability one quits if raided multiplied by the conditional expected job satisfaction of a quitter, option value is higher the greater a professor's productivity. Thus, unlike the typical case, signaling may occur even if the marginal cost of signaling is independent of the productivity of professors. However, at least with a uniform distribution of job satisfaction, signaling is not efficient unless the marginal cost of signaling is sufficiently lower for more productive faculty.

Appendix

A general distribution for job satisfaction

Let S have a density f(S) on (-∞, ∞) with a c.d.f of F(S). Following the analysis in Section 3, p_L = 1 - F(-m), and p_H = 1 - F(W_C-x_H). Note F(W_C-x_H) > F(-m) for W_C > x_L. We then have option value---the probability of quitting times conditional expected satisfaction of a quitter---of $p_H \overline{S}_H$ and $p_L \overline{S}_L$:

$$p_H \overline{S}_H = \int_{W_C - x_H}^{\infty} S f(S) dS , \tag{A1}$$

$$p_L \overline{S}_L = \int_{-m}^{\infty} S f(S) dS , \tag{A2}$$

$$p_H \overline{S}_H - p_L \overline{S}_L = -\int_{-m}^{W_C - x_H} S f(S) dS > 0. \tag{A3}$$

Thus, as argued in Section 3, option value is higher for Hs than for Ls for any continuous distribution of S. Following the analysis in Section 3, we have, when b = 1:

$$I_H - I_L = \overbrace{(p_H - p_L) x_H}^{1} + \overbrace{p_H \overline{S}_H - p_L \overline{S}_L}^{2} + \overbrace{(1 - p_H)(W_C - x_L)}^{3} \quad . \tag{A4}$$

In eq.(A4), terms {2} and {3) are positive, and term {1} is negative. Thus, signaling does not necessarily occur if b =1 .

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