The Payment of Professors:
Implications for Professorial and Student Human Capital

by

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Abstract

Adam Smith's proposal for paying professors was intended to induce increased professorial human capital. With social welfare assumed to be the value of student learning minus the opportunity cost of faculty time, if students have imperfect information about what they learn, publications may be used to measure faculty human capital, and may increase social welfare *even if they have no direct social value*. A school's reward for publications will be higher when 1) student evaluations of what they learned are relatively inaccurate, and 2) professorial human capital is relatively important for student learning. Given 1) and 2), social welfare may even increase if a school does not value student learning if the alternative is to only use student evaluations.

I. Introduction.

Adam Smith criticized the quality of teaching in the (allegedly) great English universities (Rosenberg, 1979). Smith believed professorial pay should be based on student assessment of teaching quality (Rosen, 1987). More recently, critics have argued many universities emphasize research at the expense of undergraduate education. Some of these criticisms are found in books like *Profscam* (Sykes, 1988), *Imposters in the Temple* (Anderson, 1992), and *Inside American Education* (Sowell, 1993). Smith's concern was professors spent too little time acquiring human capital, thus limiting their ability to produce student human capital. For reasons discussed below, in the modern era, Smith's proposal for paying professors would not likely achieve his objective.

The argument herein is professorial pay generally should be based both on some input from students, and on an indirect measure of faculty knowledge: publications. Although several authors have suggested publications may signal professorial knowledge, none has considered a model in which professors spend time in both teaching and scholarship, when both are inputs into student learning, and scholarship increases faculty human capital and is also required for publications. The focus of this paper is on a model of educational production when learning is imperfectly measured, universities cannot directly observe scholarship, publications may be used as a measure of scholarship (professorial knowledge or human capital), and professorial pay may be based on publications and the evaluation of teaching.[1]

In the modern university, students and employers have incomplete knowledge of what the former have learned. In order to ensure professors maintain their level of scholarship, presumably an input in student learning, universities may base professorial pay in part on peer evaluation of a measure of scholarship: publications. Diamond (1993) suggests university students are not capable of judging what or how they should be taught. Lazear (1976) argues publish or perish is a rational response to the inability to measure teaching. Paul and Rubin (1984) suggest publications signal professorial knowledge. Siow

[1] Rothschild and White (1995) ignore the input of faculty teaching and scholarship/human capital in their model of the production and pricing of higher education.

(1997) provides evidence more research serves as a signal of faculty quality and attracts more able students. Becker, Lindsay, and Grizzle (2003) demonstrate students pay more to attend schools in which professors engage in research. The latter find better students are more sensitive to academic quality; thus a higher level of publications at a school generates more able student applicants.

One reason for using publications to measure professorial human capital is student evaluations of teaching are of limited value. McKenzie (1975) argues students only can tell whether a professor is late for class and is sufficiently competent to teach the course. Forbes and Paul (1991) claim the widespread use of student evaluations is due to their ability to measure delivery. Weinberg *et al.* (2007) use data from introductory and intermediate (micro) economics courses at Ohio State University, and conclude students do not tend to understand the amount of human capital produced in class. Evaluations are problematic even with on-the-job training, where one might expect trainees have a good comprehension of what they have learned. Kristensen (2006) found almost no relation between an objective measure of learning and eleven subjective measures of satisfaction with training.

When Adam Smith taught at the University of Glasgow, professors were paid a fixed annual salary, and also received fees collected by the professors from students.[2] Consider why today such a payment scheme is neither necessary nor sufficient to achieve Smith's objective of increasing the level of professorial and student human capital.

First, although Smith endorsed the payment of fees by students to professors, this specific method of pay is not what is important. Currently, many universities base professors' pay raises on student evaluations,[3] which can accomplish Smith's objective of tying professors' pay to student input. Making professors' pay sensitive to student assessment of teaching does not require the explicit payment of fees from students to professors.[4]

[2] At some point, a professor was entitled to a house that could be used to board students and earn additional income. The majority of Smith's income may have come from student fees and income from boarders. Smith's salary in 1764 was 44 pounds sterling. His annual income appears to have ranged from 150 to 300 pounds sterling, about 100 pounds of which came from fees, and, as much as 100 pounds of which came from boarders. See Scott (1937).

[3] See Becker and Watts (1999), the results from which are discussed in Section VI below.

[4] Rosen (1987) argued education now reflects a complex bundling and certification problem, so there is no reason for the payment of fees by individuals to professors. Also, he believed the real problem in British universities was the absence of competition.

Second, in Smith's time, education was basically a consumption good. In the U.S., from 1636 until the late nineteenth century, universities were small and supplied ministers and "gentlemen" with a moral education not related to careers (McCormick and Meiners, 1988). If a student simply wishes to learn Shakespeare or a foreign language, it is relatively easy for the student to determine how much has been learned.[5] Similarly, for narrow vocational education, it may be relatively easy to test to see what students have learned. For the broader learning generally obtained at modern universities, it may be more difficult for students to measure what they have learned, and to accurately communicate this information to academic administrators.

Third, Smith was apparently not just concerned with what one might call *teaching*---communicating knowledge possessed by a professor. He seems to have been interested in the level of faculty human capital or scholarship. When Smith bemoaned the poor quality of teaching in English universities, he noted the low level of intellectual inquiry in those schools (Rosenberg, 1979). He believed schools with smaller financial endowments that depended on their reputations for subsistence were "...obliged to pay more attention to the current opinions of the world."[6] Further, Smith argued (regarding the faculty at well-endowed universities): "If the teacher happens to be a man of sense, it must be an unpleasant thing to him to be conscious, while he is lecturing his students, that he is either speaking or reading nonsense..."[7]

Consider the evolution of North American universities as described by Siow (1998). Antebellum universities offered a liberal education with few electives and little specialization; teaching was all that mattered. Throughout the nineteenth century, there was a shift away from the classics towards science. Research-oriented universities were founded in the latter part of the century (John Hopkins in 1879, Clark in 1888, and the University of Chicago in 1891). State and land-grant universities emphasized practical

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These reasons notwithstanding, professors' performance should be a function of the method by which they are paid, and thus the extent to which student input determines professorial pay may be important.

[5] As Adam Smith argued, "When a young man goes to a fencing or a dancing school, he does not, indeed, always learn to fence or to dance well; but he seldom fails of learning to fence or dance" (Smith, 1976, p.764 [original 1776]). One wonders if Smith read Benjamin Franklin, who, using the pseudonym Silence Dogood (1722), wrote about Harvard: "where...they learn little more than how to carry themselves handsomely, and enter a Room genteely, (which might as well be acguir'd at a Dancing-School,)..."

[6] Smith, 1976, p.773.

[7] Smith, 1976, p.763.

and technical education and research. Given the changes in higher education since Adam Smith's era, and given Smith's concern with the level of professorial scholarship, one who supports Smith's critique of higher education might believe professorial pay should be based on student input, to the extent students can at least judge teaching in the narrow sense, and on peer-reviewed publications, which serve as a measure of professorial scholarship.

II. The basics of the model.

The school's objective

In order to focus on the value of publications in measuring professorial human capital, it is assumed for now a school places no direct value on publications. This assumption means the model will tend to understate compensation for publications relative to rewards for teaching, but, because of the criticism too much time is devoted to publications, it is of interest to examine the social value of publications when they have no direct value (social or private). In Sections VII and VIII, a direct private value for publications will be considered.

Student human capital

Suppose a school values the probability students learn, P. Normalizing the number of students and professors at a school to one, let y and t equal the fraction of faculty time spent in scholarship and teaching respectively, where y does not include additional time required for scholarship to be converted to publications. Scholarship means the time spent by professors in staying abreast of the discipline, that is, in enhancing their human capital. It is assumed there is only one type of faculty member. The probability student learning takes place is assumed to take the following simple form:

$$P = \alpha y + (1-\alpha)t. \qquad (1)$$

Thus, if $0 < \alpha < 1$, there is some chance learning occurs without the professor spending time in either scholarship or teaching, so long as some time is devoted to one of those activities. Since $y + t \leq 1$, unless $y = \alpha = 1$ or $t = 1-\alpha = 1$, the probability student learning occurs is less than one.

Publications

Let q equal a quality-weighted index of the level of the professor's publications. It is assumed $q = y$, provided the professor spends the amount of time ry in converting scholarships to publications, $r > 0$. The total work time for the professor is $t + (1+r)y$ if publications are produced, and $t + y$ otherwise. The effort cost to the professor, C, is assumed to be separable in teaching and in producing scholarship and publications:[8]

$$C = t^2 + [(1 + r)y]^2, \qquad (2)$$

where *eq.*(2) assumes publications occur. Otherwise, $C = t^2 + y^2$.

The school and evaluations

The school values student learning by v, and is assumed to maximize the value of expected student learning, vP, minus what it must pay its professor. If the professor can earn ω elsewhere with zero effort, then the wage that is necessary to attract the professor must at least equal ω plus compensation for effort cost, C.

The school can use costless student evaluations to try to determine if learning occurs. Suppose an evaluation is either "good" or "bad." Let the probability of a good evaluation be ρ:

[8] If increasing time spent in either activity becomes tiresome, independent of the total time spent at work, then $\frac{\partial^2 C}{\partial t \partial y} = 0$. Allowing for the possibility $\frac{\partial^2 C}{\partial t \partial y} > 0$ complicates the analysis without adding much value.

$$\rho = \lambda P + (1-\lambda)t, \tag{3}$$

with $0 \leq \lambda \leq 1$. Thus, it is assumed evaluations are based on faculty time spent in teaching, *t*, and on student learning, the latter also a function of *t*. A perfectly informative evaluation ($\lambda = 1$) means the probability of a good evaluation equals the probability learning occurred, and the opposite case ($\lambda = 0$) means the evaluation is based solely on the professor's time spent in teaching. The logic of the assumed evaluation function is twofold. First, unless a student is totally uninformed ($\lambda = 0$), an increased likelihood of student learning should imply a greater probability of a good evaluation. Second, teaching time has a direct positive impact on the probability of a good evaluation unless a student is totally informed ($\lambda = 1$). Adam Smith believed little professorial knowledge or classroom effort was required to convince students they had a competent instructor:

> "The slightest degree of knowledge and application will enable him to do this without exposing himself to contempt or derision, or saying anything that is really foolish, absurd, or ridiculous."[9]

III. Faculty scholarship and teaching with perfect information.

As a benchmark, consider a world when the professor's time spent in scholarship and teaching, *y* and *t*, are verifiable by the school at which the professor is employed.[10] In this case, neither teaching evaluations nor publications are required. The professor's effort cost is $t^2 + y^2$. The school is assumed to simply set the desired levels of *t* and *y*,[11] subject to the constraint the wage equals $\omega + t^2 + y^2$, and to *eq*.(1). Thus the school maximizes the following with respect to *y* and *t*:

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[9] Smith, 1976, p.763.

[10] With only one type of professor, observing *y* means the school knows the level of professorial human capital.

[11] Alternatively, the school could set a wage based on *t* and *y* in order to induce the desired levels of these two variables. The results would be unchanged.

$$vP - y^2 - t^2 - \omega. \quad (4)$$

The first-order conditions yield:

$$y = \frac{v\alpha}{2}, \quad (5)$$

$$t = \frac{v(1-\alpha)}{2}. \quad (6)$$

From the first-order conditions, $\frac{y}{t} = \frac{\alpha}{1-\alpha}$. These conditions were derived assuming the time constraint ($y + t \leq 1$) does not bind, which requires $v < 2$. If the time constraint binds, $y = \alpha$ and $t = 1-\alpha$. Herein, it is assumed $v < 2$, so the time constraint does not bind.[12] Allgood and Walstad (2006) provide evidence for a non-binding professorial time constraint. For example, they find ten more hours per week on research translates into about three hours less on teaching. Milem, Berger, and Dey (2000) found significant work time increases for professors over a roughly twenty year period beginning in 1972. Also, in the model herein, if the time constraint does not bind, then schools that value student learning more (have a larger value for v) are able to demand professors spend more time in teaching and scholarship, which seems to be reasonable.[13]

IV. Imperfect information: teaching evaluations but <u>no</u> publications.

As a second benchmark, consider the case when the school can not directly observe either t or y, and, for whatever reason, does not use publications to indirectly measure y. The school pays the professor

[12] When the time constraint does not bind, total time at work equals $v/2$. When publications are desired by schools, the assumption $v < 2$ will still ensure the time constraint does not bind. With publications, total time at work actually decreases (relative to the perfect information world) because inducing a given level of scholarship is more costly to a school since the time required to demonstrate scholarship (via publications) increases. This cost effect dominates the requirement of more time, ry, for publications so total work time falls.

[13] With or without a binding time constraint, $\frac{y}{t} = \frac{\alpha}{1-\alpha}$. A binding time constraint only affects the levels of y and t.

a bonus equal to W_G if a good teaching evaluation is received. The professor then chooses y and t to maximize expected compensation net of effort cost. With W_0 a fixed payment to ensure the application constraint holds (that is, total compensation equals $C + \omega$), the professor maximizes:

$$\rho W_G + W_0 - y^2 - t^2. \tag{7}$$

The first-order conditions for the professor yield:

$$y = \frac{\alpha\lambda W_G}{2}, \tag{8}$$

$$t = \frac{(1-\alpha\lambda)W_G}{2}. \tag{9}$$

From *eqs.*(8) and (9), $\frac{y}{t} = \frac{\alpha\lambda}{1-\alpha\lambda}$. If $\lambda = 1$, so the teaching evaluation is fully informative, $\frac{y}{t} = \frac{\alpha}{1-\alpha}$, as was the case with perfect information. Below, it will be demonstrated $W_G = v$ if $\lambda = 1$, so the levels of y and t would also be identical to their values with perfect information. If $\lambda = 0$, so the teaching evaluation depends only on the professor's time input into teaching, and not on whether student learning occurred, $y = 0$ and $t = W_G/2 = (1-\alpha)v/2$, the latter equality demonstrated below. Professors will devote no time to scholarship if evaluations do not depend on student learning, but evaluations will induce the perfect information level of time in teaching. Note, although t is the same when $\lambda = 0$ and when $\lambda = 1$, it is not the case t is independent of λ, as will be discussed below.

The school's decision problem is again to maximize the value of expected student learning, vP, minus what it must pay its professor, but now it chooses W_G when both y and t are functions of W_G (*eqs.*(8) and (9)). Also, the school faces the application constraint:

$$W_0 + \rho W_G = \omega + t^2 + y^2. \tag{10}$$

Substituting for $W_0 + \rho W_G$ from *eq.*(10), the school again maximizes $\{vP - y^2 - t^2 - \omega\}$, yielding:

$$[v(1\text{-}\alpha) - 2t]\frac{\partial t}{\partial W_G} + [v\alpha - 2y]\frac{\partial y}{\partial W_G} = 0. \tag{11}$$

Proposition One. If $0 < \lambda < 1$, t exceeds its perfect information level and y is less than its level with perfect information.

Proof. Using *eqs.*(8) and (9), both t and y are linear in W_G, so, with $\frac{\partial t}{\partial W_G}$ and $\frac{\partial y}{\partial W_G}$ both positive, the second-order condition for a maximum clearly holds. Now either 1) both t and y are at their perfect information levels, so the bracketed terms in *eq.*(11) are zero, which (see below) occurs only if $\lambda = 1$; or 2) one of the two time inputs is below and the other is above its perfect information level. Using *eqs.*(8), (9), and (11), we have:

$$W_G = \frac{v\left[\alpha^2\lambda + (1-\alpha)(1-\lambda\alpha)\right]}{\alpha^2\lambda^2 + (1-\lambda\alpha)^2}. \tag{12}$$

If $\lambda = 1$, $\rho = P$, $W_G = v$, $y = v\alpha/2$, and $t = v(1\text{-}\alpha)/2$. Thus, if the student evaluation is an unbiased estimate of the probability learning occurred, faculty time inputs in teaching and scholarship equal their levels under perfect information. Although publications have been assumed away in this section, if $\lambda = 1$, publications would not be demanded by the school.

If $\lambda = 0$, $W_G = v(1\text{-}\alpha)$, $y = 0$, and $t = v(1\text{-}\alpha)/2$. When the student evaluation is not related to the probability learning occurred, the payment for a good evaluation is lower than when the evaluation is an unbiased estimate learning occurred, no time is devoted to scholarship (since it has no impact on evaluations), and the time to devoted to teaching is the same as when $\lambda = 1$.[14]

Numerical examples demonstrate $t \geq (1-\alpha)v/2$, with the equality holding only if λ equals either zero or one. For example, suppose $\alpha = .25$, so $(1-\alpha)v/2 = .375v$. Then $t = .382v$ if $\lambda = .25$, $t = .385v$ if $\lambda = .5$, and $t = .383v$ if $\lambda = .75$. Thus, if $0 < \lambda < 1$, t exceeds its perfect information level, and y is less than its level with perfect information. ■

V. Imperfect information: teaching evaluations <u>with</u> publications.

Presumably, scholarship is necessary for publications. If scholarship is also valuable in student learning, the school may require publications in order to ascertain the level of knowledge of the professor. As George Stigler argued:

> "A capable research scholar has a deeper knowledge than the non-scholar: one treats a subject with much more care if one's thoughts are going to be published and reviewed by hawk-eyed colleagues. A research scholar in general has a higher level of energy than the non-scholar. Of course there are research scholars who are so magnificently incomprehensible and one-sided that in simple mercy to students they should be forbidden to enter a classroom. For ever such creature there are surely a dozen lazy, poorly informed non-research scholars. The correlation between teaching ability and research ability is imperfect but it is not negative."[15]

Suppose the school pays W_q for each publication,[16] in addition to paying W_G when a good evaluation is received and the fixed amount W_0.

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[14] Although intuition may suggest $\frac{\partial W_G}{\partial \lambda} > 0$, this is not true for all values of α and λ.

[15] Stigler, 1989, p.17.

Proposition Two. Teaching time (t) will equal the level attained with perfect information. Time spent in scholarship (y) will be smaller than with perfect information as long as time is required to turn scholarship into publications (r >0).

Proof. The professor now chooses y and t to maximize:

$$\rho W_G + qW_q + W_0 - [(1 + r)y]^2 - t^2. \tag{13}$$

The first-order conditions for the professor yield:

$$y = \frac{\alpha\lambda W_G + W_q}{2(1+r)^2}, \tag{14}$$

$$t = \frac{(1-\alpha\lambda)W_G}{2}. \tag{15}$$

Note, $\frac{\partial y}{\partial W_G}$, $\frac{\partial y}{\partial Wq}$, and $\frac{\partial t}{\partial W_G}$ are all positive if $0 < \lambda < 1$. Now the school has the application constraint:

$$W_0 + \rho W_G + qW_q = \omega + t^2 + [(1 + r)y]^2. \tag{16}$$

Using the application constraint, the school maximizes $\{vP - [(1 + r)y]^2 - t^2 - \omega\}$, subject to *eqs.*(14) and (15), yielding the first-order conditions for the school:

[16] Chen and Ferris (1999) model a school that does not value publications *per se*, but uses publications as a standard for tenure in order to measure faculty human capital. However, pay is not based on publications, so there is no way to measure faculty knowledge post-tenure. They argue faculty do not like publication-based pay because of randomness in the publication process. However, they use a two-period model; in a multi-period model, randomness will be less important as good years cancel out bad ones. Herein, the tenure process is ignored, and the focus is on how pay can motivate faculty to spend time in scholarship and teaching.

$$\frac{\partial\{\bullet\}}{\partial W_q} = \left(v\alpha - 2y[1+r]^2\right)\frac{\partial y}{\partial W_q} = 0, \tag{17}$$

$$\frac{\partial\{\bullet\}}{\partial W_G} = \left(v\alpha - 2y[1+r]^2\right)\frac{\partial y}{\partial W_G} + \left(v[1-\alpha] - 2t\right)\frac{\partial t}{\partial W_G} = 0. \tag{18}$$

Using *eqs.*(14) and (15), the second-order conditions clearly hold for the school's maximization problem. Note, if $\lambda = 1$, there would be no reason for publications, so W_q would be zero. Otherwise, both W_q and W_G are positive. To see this, suppose, to the contrary, the term in parentheses in *eq.*(17) is negative, so there is a corner solution and $W_q = 0$. Then, for an interior solution for W_G, the second term in parentheses in *eq.*(18) must be positive, or $t < v(1\text{-}\alpha)/2$. However, if $W_q = 0$, only evaluations are used to motivate the professor, and, in that case, using numerical examples for α and λ, it can be shown $t \geq v(1\text{-}\alpha)/2$. Thus, both terms in parentheses in *eq.*(18) equal zero for an interior solution for W_G, so both W_q and W_G are positive if $\lambda < 1$. Using *eqs.*(14), (15), (17), and (18), we have:

$$W_G = \frac{v(1-\alpha)}{1-\lambda\alpha}\ , \tag{19}$$

$$W_q = \frac{v\alpha(1-\lambda)}{1-\lambda\alpha}. \tag{20}$$

One can easily see $\frac{\partial W_G}{\partial \lambda} > 0$, $\frac{\partial W_G}{\partial \alpha} < 0$, $\frac{\partial W_q}{\partial \lambda} < 0$, and $\frac{\partial W_q}{\partial \alpha} > 0$. The more accurate is the evaluation of teaching (the larger λ is), the less valuable publications are, the lower W_q is, and the higher W_G is. The more important faculty human capital (scholarship) is in student learning (the larger α is), the more publications are rewarded, and the lower the reward for a good evaluation of teaching. If $\lambda = 0$, $W_G = v(1\text{-}\alpha)$ and $W_q = v\alpha$. If $\lambda = 1$, $W_G = v$ and $W_q = 0$.

Consider the payments for and time spent in teaching and research. For simplicity, suppose $\lambda = 0$. Note W_q is now as large as possible. Using *eq.*(14), $q = y = \frac{v\alpha}{2(1+r)^2}$, so $qW_q = \frac{v^2\alpha^2}{2(1+r)^2}$. Using *eqs.*(3) and (15), $t = \frac{v(1-\alpha)}{2}$, and expected compensation for teaching = $\rho W_G = \frac{v^2(1-\alpha)^2}{2}$. Even if $\alpha = ½$, so y and t are equally valuable in student learning, if $r > 0$, $t > y$ and expected compensation for teaching exceeds compensation for publications. For example, if $r = 1$, so time spent in publications equals time spent in scholarship, α must exceed 4/5 in order for time spent in scholarship to exceed time spent in teaching, and must exceed 2/3 in order for compensation for publications to exceed expected compensation for teaching.[17]

Using the first-order conditions for the professor and the school:

$$y = \frac{v\alpha}{2(1+r)^2}, \tag{21}$$

$$t = \frac{v(1-\alpha)}{2}. \tag{22}$$

Thus, comparing *eqs.*(5) and (6) with *eqs.*(21) and (22), with both payment for good teaching evaluations and for publications, teaching time is the same as with perfect information, and time spent in scholarship is lower than when information is perfect if $r > 0$. ■

Total time in teaching, scholarship, and producing publications, $t + (1 + r)y$, equals:

$$\frac{v}{2}\left(1 - \frac{\alpha r}{1+r}\right), \tag{23}$$

[17] Of course total time in scholarship and publications, $y(1+r)$, will exceed teaching time for smaller values of r. For example, if $r = 1$, this occurs for $\alpha > 2/3$. Anecdotally, research-oriented schools seem to base pay heavily on publications. Assuming r is not trivial, either α is large for such schools, or they value publications directly, or both are true.

which, unless no time is required to convert scholarship into publications ($r = 0$), or scholarship has no impact on student learning ($\alpha = 0$), is less than $\frac{y}{2}$, the sum of teaching and scholarship time with perfect information. Thus, the direct effect of time required for publications is more than offset by the cost to the school of compensating the professor for this time (since professorial effort cost is assumed convex in time spent at school), so total time spent at work will be lower with imperfect information concerning faculty time inputs than with perfect information.

Using *eqs*.(8), (12), and (21), we can consider when y is larger with pay based on both publications and teaching evaluations (call this value y^*) as opposed to the case when pay is only based on evaluations (call this value y^{**}). We are more likely to find y^* larger than y^{**} when faculty human capital is relatively important in student learning (α is large), evaluations of teaching are less accurate (λ is small), and the time requirement for publishing scholarship is not significant (r is small). For example, if $\alpha = ¾$ and $\lambda = ¼$, $y^* > y^{**}$ if $r < 1.04$, but, if $\alpha = ¼$ and $\lambda = ¾$, this only occurs if $r < .14$. As shown in the next section, not surprisingly, a school is more likely to base pay on both publications and teaching evaluations, as opposed to having pay based only on evaluations (and constant terms in both cases to meet the application constraint), when α is relatively large, and λ and r are relatively small.

In sum, a school that places more value on research will tend to place less value on teaching, even if publications are not valued *per se*. Becker and Watts (1999) surveyed chairs of economics departments,[18] and found teaching was more important for both tenure and annual raises as one moves from Research I and II institutions, to Doctoral I and II institutions, to Masters I and II institutions, and finally to Baccalaureate I and II. Institutions. The percentages of these schools for which teaching is important for annual raises (tenure) are 30 (25), 40 (40), 45 (50), and 50 (60) respectively.

Empirically, merit pay that allows rewards for more publications and better teaching affects professional performance. Chant (2005) examined pay for professors at Canadian universities. He found universities that use merit pay have significantly more research grants, more citations per professor,

[18] Questionnaires were sent to 1,123 institutions, 1,008 of which were in the U.S.

higher quality students (based on entering GPAs), and higher levels of student satisfaction than do universities that do not use merit pay.

VI. Welfare analysis.

In the model herein, rewarding publications gives the school a second instrument (in addition to rewards based on the evaluation of teaching) to affect the levels of scholarship and teaching time, but publishing involves a social and private cost because of the related time requirements. The social and private value of the school's product is $\{vP - [(1 + r)y]^2 - t^2 - \omega\}$ when there are publications along with student evaluations, and $\{vP - y^2 - t^2 - \omega\}$ when there are no publications, where the first value function is evaluated using *eqs.*(21) and (22), and the second value function is evaluated using *eqs.*(5) and (6). Define $\tilde{W}_{G,SE}$ as the value of W_G when only student evaluations are used (*eq.*(12)) divided by v. Thus, $\tilde{W}_{G,SE}$ is not a function of v. Using publications and evaluations to induce scholarship and teaching time is socially and privately preferable to using evaluations only if:

$$\frac{\alpha^2}{(1+r)^2} + (1-\alpha)^2 > \left\langle \lambda\alpha^2\left(2 - \lambda\tilde{W}_{G,SE}\right) + (1-\lambda\alpha)\left(2[1-\alpha] - [1-\lambda\alpha]\tilde{W}_{G,SE}\right)\right\rangle \tilde{W}_{G,SE}. \qquad (24)$$

If $\lambda \to 0$, $\tilde{W}_{G,SE} \to 1-\alpha$ and the RHS of *ineq.*(24) $\to (1-\alpha)^2 <$ the LHS of *ineq.*(24). If $\lambda \to 1$, $\tilde{W}_{G,SE} \to 1$ and the RHS of *ineq.*(24) $\to \alpha^2 + (1-\alpha)^2 >$ the LHS of *ineq.*(24) if $r > 0$. Thus, there is some value of λ, call it λ^*, where, for $\lambda < \lambda^*$, the evaluation of teaching is inaccurate enough it pays to incur the time cost of publishing. For $\lambda > \lambda^*$, evaluations alone dominate the combination of evaluations and publishing because evaluations are relatively accurate.[19]

For example: if $\lambda = \alpha = ½$, publications along with evaluations are preferable to evaluations only if $r < .29$. A greater role for scholarship in student learning or less accuracy in evaluations implies a greater likelihood publications along with evaluations dominate evaluations only. When $\alpha = ¾$ and $\lambda = ½$, this is true for $r < .375$, and, for $\alpha = ¾$ and $\lambda = ¼$, it is true for $r < .665$.

Note, *ineq.*(24) is independent of v: a change in the value of student learning has no impact on the likelihood publications along with evaluations dominate evaluations only. The accuracy of evaluations (λ), the importance of scholarship vs. teaching in student learning (α), and the extent to which publications use time in addition to that spent in scholarship (r) are all that matter for welfare comparisons.

Since the social and private values of the school's product are identical, schools will efficiently choose whether to pay for and require publications, and will only do so if $\lambda < \lambda^*$. A low value for λ means it is difficult to ascertain whether learning takes place in a class. This might occur when a school has large class sizes and a large variance in student quality, both of which may be true for public, research-oriented schools. Elite research-oriented private schools also tend to have large introductory classes, although the variance in student quality in these institutions may be less than in public schools.

VII. The school cares about publications (only).

To this point, it has been assumed the school places no value on publications *per se*. However, as noted in Section I, a number of commentators have argued many schools emphasize research at the expense of undergraduate education. In order to address the issue of too much emphasis on research, consider the extreme case where the school *only* cares about publications, and there is *no* direct social

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[19] As discussed in footnote fourteen, regarding $\frac{\partial W_G}{\partial \lambda}$, it is possible $\frac{\partial \tilde{W}_{G,SE}}{\partial \lambda}$ is not positive for all parameter values, so one can not rule out multiple crossing points when comparing welfare. Since public and private returns are the same, and $\frac{\partial \tilde{W}_{G,SE}}{\partial \lambda}$ is generally positive, it is not worthwhile to consider the possibility of multiple crossing points.

value from publications. Of course, publications still have some social value to the extent they induce a level of scholarship that is socially preferable to that attained with no publications. Suppose the school values a publication by μ. Since the school does not value student learning, it will not evaluate teaching and will reward only publications, again paying W_q per publication. The professor then chooses y to maximize $\{qW_q + W_0 - [y(1+r)]^2\}$, and the school chooses W_q to maximize $\{\mu q - [y(1+r)]^2 - \omega\}$, given y depends on W_q from the first-order condition for the professor. The professor's maximization problem implies:

$$y = \frac{W_q}{2(1+r)^2}, \tag{25}$$

and the schools' maximization problem yields:

$$(\mu - 2y[1+r]^2)\frac{\partial y}{\partial W_q} = 0. \tag{26}$$

The two first-order conditions imply $W_q = \mu$. Thus, the payment for publications is set equal to the value the school places on them, and $y = \frac{\mu}{2(1+r)^2}$.

Clearly, the social optimum would be attained if the school did not value publications *per se,* and, if $\lambda < \lambda^*$, rewarded publications and good teaching evaluations, or, if $\lambda > \lambda^*$, rewarded only good evaluations. However, if, as the critics mentioned above allege, some schools have too little interest in student learning, it is also possible some schools may place too little value on publications, and may not reward them, even when it is socially valuable to do so (because of the value of faculty scholarship in student learning). Those who allege too much time is devoted to publications argue schools are "captured" by faculty who prefer research to teaching. However, if faculty may capture a school, when a school is dominated by those who are not interested in research, it also can be the case the faculty stifle attempts to reward research (and hire more able faculty).[20]

It may then be of interest to compare two extreme possibilities. *In CASE I, the school only values publications, and, in CASE II, the school values only student learning, but does not reward publications, even if* $\lambda < \lambda^*$. Thus, one can determine when (if ever) a school that ignores student learning generates more social value than does a school that ignore publications. To enable us to compare the two cases, suppose $\mu = \phi v$, $\phi > 0$. Table One shows the results for different values of λ, α, and r.[21]

From the first two rows of Table One, if evaluations are not too inaccurate (say, $\lambda \geq ½$), and, scholarship is relatively unimportant in student learning (say, $\alpha \leq ½$), then welfare is not higher in CASE I than in CASE II even if no time is required to convert scholarship into publications ($r = 0$). From rows three through five, if scholarship is sufficiently valuable ($\alpha = ¾$ in this example) when evaluations are relatively neutral ($\lambda = ½$), there are small enough values of r for CASE I welfare to exceed welfare in CASE II. Rows seven and eight demonstrate welfare is higher in CASE I than in CASE II for a wide range of values for r if $\alpha = ¾$ and $\lambda = ¼$.

Thus, a school that only values publications (when publications are assumed to have zero social value) could produce higher social welfare than a school that refuses to reward publications, but this would occur only when scholarship is relatively valuable in student learning, evaluations are relatively inaccurate, and the time required to turn scholarship into publications is not too high.

VIII. The School chooses whether to value only publications or only student learning (without publications).

[20] Hosios (2003) models a university as a place where professors use majority voting to determine how they are evaluated and compensated.

[21] The explicit derivations for welfare in the two cases are omitted for brevity. Note, a necessary condition for welfare to be positive when the school values only publications is $2\alpha > \phi$: scholarship must be sufficiently valuable in student learning relative to the private value the school places on publications or welfare will be negative when only publications are valued by the school.

In the previous section, we considered a school that could value either publications or student learning. Now suppose the school can choose what it will value. One reason for this choice is there may be costs to the school of publishing not considered herein (*e.g.* equipment, laboratories, and released time from teaching).[22] Alternatively, if the school may be captured by the faculty, it may be the faculty's private payoff we consider, so, when the private return in CASE I exceeds that in CASE II, the faculty are more likely to choose a regime in which publications only are valued.

Since the results depend on the values of α and λ, and since, as we have seen, valuing publications does not socially dominate valuing student learning (with no publications) if α is small and λ is large, consider the case where α = ¾ and λ = ¼ . The private value to the school in CASE I is (using $y = \frac{\mu}{2(1+r)^2}$):

$$\frac{\mu^2}{4(1+r)^2} - \omega . \tag{27}$$

With α = ¾ and λ = ¼, the private value to the school in CASE II is approximately:

$$.0425v^2 - \omega . \tag{28}$$

With $\mu = \phi v$, the school prefers CASE I to CASE II if:

$$\phi^2 > .17(1+r)^2. \tag{29}$$

[22] If these costs equal *k*, both the social and private payoff with publications only would be reduced by *k*. Critical values shown in Figure One for when CASE I would be socially and privately preferred to CASE II would change, the v^2 term would not drop out of *ineq.*(29), and the analysis would also have to assume values for *v*. Thus, for simplicity, *k* is assumed to equal zero herein.

Using Figure One, consider the situation when $r = .5$. Recall, in CASE I, with publications only valued by the school, $t = 0$.

Publications are not and should not be preferred.

If the school places a relatively low value on publications *per se* ($\phi < .379$), publications will not and should not be preferred to student learning (and not rewarding publications). Now ϕ is low enough so, with $t = 0$, the privately optimal level of y when a school values publications leads to welfare below that when only evaluations are used and student learning is valued, even though y is three times as important as t in student learning.

Publications are not but should be preferred.

If publications are valued somewhat more ($.379 \leq \phi < .618$), the school will not choose publications over student learning, but should do so. Now ϕ is high enough y would be at a level where welfare would be higher in CASE I than in CASE II, but it is not privately optimal for the school to choose CASE I over CASE II. Thus, a school like this has an inefficiently low level of publications (zero).

Publications are and should be preferred.

With even larger values for publications ($.618 \leq \phi \leq 1.121$), publications will and should be chosen by the school over student learning. Now ϕ is large enough the school prefers CASE I to CASE II, and the level of publications improves welfare (vs. CASE II).

Publications are but should not be preferred

Finally, for values for publications that are still higher ($1.121 < \phi$), the school prefers CASE I to CASE II, but welfare with publications is lower than with CASE II. Even though y is more valuable than t for student learning, y is too high in CASE I, which, with $t = 0$, yields welfare lower than with CASE II. Of course, as suggested by Table One, if evaluations are relatively accurate (λ is high), and professorial scholarship is relatively unimportant in student learning (α is low), CASE I will never be socially preferable to CASE II (even if $r = 0$), but publications only will be chosen as long as i*neq*.(29) holds.

It has been assumed herein there is no direct social value for publications. This approach is somewhat analogous to that in Spence (1974), where he assumed no social value for education in order to examine whether a purely private return---ability signaling---might exist. The difference between the educational signaling case and that of publications revealing something about professorial human capital is a social return to publications still occurs because publications require faculty scholarship, with the latter an input in the production of student human capital. Thus, publications might improve social welfare even if they do not directly do so.

In this section, because schools are assumed to either demand publications, ignoring the value of student learning, or value student learning, ignoring the value of publications in revealing faculty human capital, we find those with the lowest value for publications do not and should not require publications, those with the highest value for publications demand them when they reduce social value, and those with intermediate values for publications may demand them when they should do so. The model thus lends some support to the notion excessive publishing may occur in academia, but it also suggests there are cases when the amount of publishing improves welfare, or could so if a school that did not reward publications would reward them.

IX. A digression on peer review

Ellison (2002) documents the slowdown in the publication process in economics. He also finds (Ellison, 2007) established scholars at the best universities may have substituted other venues, including on-line working paper archives, for publications in the top, peer-reviewed journals. In the model herein, a slowdown in the publication process implies an increase in r, which, in any of the cases we considered, would yield a reduction in the time spent by professors on scholarship, y. However, no possibility for multiple publication venues was considered herein. Thus, an increase in r for peer-reviewed journals may have induced the development of alternative outlets for research that involve less faculty time, and may, albeit not as well, serve the role of quality certification. One possibility is such certification is less important for established scholars, but others are still forced to endure the peer review process. Although a larger r might seem inconsistent with the apparent growing emphasis on research among universities, it is possible the increase in r results because the demand for publications by universities (and thus the supply of articles by professors) has outpaced the growth in peer-reviewed journals. In terms of our model, either α or v has increased (or both have) to more than offset increases in r, causing y, or at least $y(1+r)$, to increase.

X. Conclusions.

Adam Smith was concerned with the level of faculty scholarship. His proposal---direct payment of faculty by students---may have been sensible when education was essentially a consumption good, the value of which was fairly easy to observe by students. Today, given students and employers have incomplete knowledge of what the former have learned, pay based partially on peer-reviewed publications, in order to ensure faculty maintain their level of scholarship, and on student input, to the extent students can imperfectly judge what they have learned, may be optimal to accomplish Smith's objectives.

When students have imperfect information about what they learn, publications may be used to measure faculty knowledge, and may increase social welfare *even if publications have no direct social value*. A school's reward for publications will be higher when 1) student evaluations of what they learned are relatively inaccurate, and 2) faculty human capital is relatively important for student learning. Given

1) and 2), welfare may even increase if a school ignores student learning if the alternative is to only use student evaluations.

Chant (2005) suggest merit pay may not be appropriate for universities with more emphasis on teaching, particularly if judging teaching is difficult relative to judging research. This may be true if the value of student human capital produced is low---v is small in the model herein. However, some teaching-oriented private universities produce graduates who are highly regarded by employers, or are admitted to good professional and graduate schools, suggesting v is relatively high for those universities. There seems to have been an increased emphasis on research in recent years at such universities, which may be the result of an increased value for their students' human capital. Also, if, for whatever reason, it has become more difficult to evaluate teaching than research in recent years, λ would have declined, and the increase in v and decrease in λ would both imply an increased reward for publications (increase in W_q). Universities that do not directly value publications may still demand merit pay, and the relative rewards for teaching and publications will depend on α and λ.

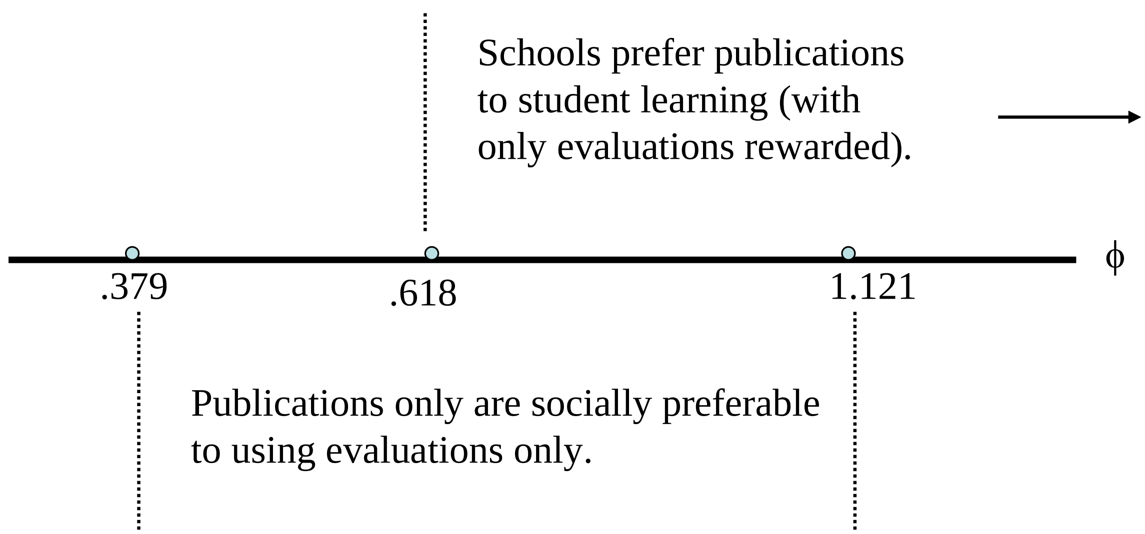
The social justification for faculty publications may be even greater than was found in this paper, even without considering the value of knowledge created by (at least some) research, Herein, only one type of professor was considered. With more than one level of professorial ability, there may be a social value in matching more able professors and students. In that case, publications may serve a signaling role (Spence, 1974), with the more able professors publishing more than the less able. The social implications of such ability signaling are left for a sequel.

Table One. When is social welfare higher when the school values only publications vs. valuing only teaching and not rewarding publications.

λ	α	r	Result
¾	¼	0	Never*
½	½	0	Never*
½	¾	0	$.3 < \phi < 1.2$
½	¾	1/8	$.423 < \phi < 1.077$
½	¾	¼	Never*
¼	¾	0	$.124 < \phi < 1.377$
¼	¾	½	$.379 < \phi < 1.121$

*Assuming only real values for ϕ.

Figure One



$\alpha = \frac{3}{4}$, $\lambda = \frac{1}{4}$, & $r = \frac{1}{2}$.

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