EVALUATING UNIVERSITY GRADUATES: PRESTIGE VERSUS MERIT

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Abstract. I study a game in which universities compete by making unobservable investments in education quality. Subsequently, the graduates are considered for a single placement by an organization. A merit-based evaluator compares the realized skill of each graduate. A prestige-based evaluator only observes a noisy signal of the universities' relative education quality. Though a prestige-based evaluator ignores valuable information, I derive conditions under which an increase in the probability of the prestige-based evaluator incentivizes higher investment and benefits the organization.

Key words and phrases.
JEL: L13, L15, D83.

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1. Introduction

In the mythology of professional school admissions and firm hiring, all candidates are treated equally; admission and employment decisions are based on a substantive assessment of merit that incorporates all relevant information about a candidate's quality and potential contributions. Recent analyses of hiring and admissions practices suggest that reality is far from this myth. "Across firm type, the prestige of one's educational credentials was the most common criteria used to solicit and screen resumes. Employers formally constrained the bounds of competition for elite jobs to students holding an elite educational credential" (Rivera 2011). In other words, a high performing graduate of a less prestigious university—who are likely to be highly qualified—may not even be considered for admission or employment, which would instead be offered to a less qualified graduate from a more prestigious university. Though recruiters and evaluators are interested in identifying qualified candidates "they largely believed that the status of a candidate's educational affiliation was a reflection of his/her intellectual... worth," and therefore, considering only candidates with elite backgrounds is a simple way to reduce the cost of the evaluation process (Rivera 2011).

This paper analyzes the positive and normative impacts of prestige-based evaluations. How do such hiring practices affect universities incentives to invest in education quality? Although prestige-based evaluations ignore candidates' merits, could such practices nevertheless be beneficial for an organization? The analysis focuses on a simple model of an evaluation process featuring both merit-based and prestige-based evaluations, endogenous investment in education quality, and a public signal that reveals information about relative investment, a proxy for the complex process that determines a university's "prestige."

In the model, two universities compete for a single placement at a desirable organization. A graduate may be one of to types: high skill or low skill, and high skill graduates are more valuable to the organization than low skill graduates. Each university simultaneously invests in education quality, which determines the probability that its graduate has high skill. Universities' education investments are private. Both graduates then apply for the placement. The organization evaluates the graduates in one of two ways. If its evaluator follows a merit-based approach, then he or she evaluates the graduates based on their actual skill, selecting a high skill graduate over a low skill graduate, regardless of the graduate's alma mater. If the evaluator follows a prestige-based approach, then he or she observes a noisy public signal about relative investment in education quality. The prestige-based evaluator then chooses the graduate that she believes is more likely to have high skill. In other words, even though information about the candidates' true abilities is available (and is utilized under merit-based hiring), the prestige-based evaluator selects the graduate of the university that he or she believes is more likely to produce a high skill graduate. In essence, the prestige-based evaluator ignores information about the true skill of the actual candidates, evaluating them based solely on his or her beliefs about the relative quality of their alma maters. The probability that the employer is prestige-based is commonly known, but the universities do not know the hiring practice that will be used at the time that they invest in education.

This model has multiple equilibria, which have different properties. In one equilibrium, the prestige-based evaluator is *closed minded*: she does not pay attention to the public signal when selecting the graduate. New information about education quality does not affect the evaluator's perception of a university's prestige. In this case, the prestige-based type acts in a predetermined way, assigning the job to the graduate of the school that he or she initially believes invested more in education quality. Consequently, actual investment can only affect the decision of the merit-based employers. In equilibrium, each university selects a pure strategy. Since he or she can perfectly anticipate relative investment, the prestige-based evaluator is justified ignoring the ranking, attributing any realization that deviated from his or her expectation to noise. Because competition among universities is confined to the subset of merit-based evaluator, increasing the probability that the evaluator is prestige-based dampens competition, reducing investment by both universities. This equilibrium reflects the "conventional wisdom" of prestige-based hiring: prestige-based evaluators may favor the graduate of one of the universities, independent of their realized skills. Increasing the probability that the evaluator is prestige-based reduces education quality and the probability of selecting a high skill candidate, reducing the organization's payoff.

In the other type of equilibrium, the prestige-based evaluator is *open minded*—he or she assigns the job to the graduate of the university that is reported by the ranking to have higher education quality. In other words, changes in education quality transform fluidly into the university's "prestige." From the perspective of a university, investing a bit more than the other university increases the probability of being ranked higher, and it leads to a significantly higher probability of placing the graduate. This creates incentives for each university to "leap frog" the investment level of their rival. These effects result in a mixed strategy equilibrium, in which universities choose investments unpredictably from an interval of high investment levels. Because of this unpredictability, the public signal is decisive in shaping the prestige-based's view of the universities' relative quality. In this equilibrium, the "leap frog" effect that drives high investment arises from the desire to be chosen by a prestige-based evaluator; therefore, increases in the probability of encountering such an evaluator strengthen this effect. It follows that an increase in the probability of prestige-based evaluator, translates into higher levels of equilibrium investment in education quality. The effect on investment can be so strong that, despite the fact that prestige-based evaluators may make mistakes, increasing the probability that the evaluator is prestige-based may benefit the employer. This equilibrium reveals novel effects, absent from the typical view of prestige-based hiring. If public information about education quality—ratings, for example—are informative and incorporated fluidly into the evaluator's view of university prestige, then a prestige-based evaluator hires from the school that is more likely to deliver a highly skilled graduate. Increasing the probability that the evaluation is prestige-based increases expected education quality. Because prestige-based evaluators may select the lower ability candidate, while merit-based evaluations never do, the increase in the probability of a prestige-based evaluation creates a tradeoff for the organization.The effect on investment evaluator generally implies that an evaluation protocol that is purely based on merit is suboptimal for the organization.

Related Literature. As mentioned above, the paper is related to a body of work in sociology that documents prestige-based hiring practices among elite employers (Rivera 2011, 2012, 2015). One contribution of the present work is to integrate these findings into an economic model of university competition. A significant literature within economics studies selection problems in the absence of monetary transfers. Most related is Boleslavsky and Cotton (2015). This paper develops a model in which universities compete both by investing in education and by designing grading policies, showing that fully informative grading is not necessarily optimal for the hiring firm. Though similar in spirit to the present work, Boleslavsky and Cotton (2015) relies strongly on the observability of investment; if investment is unobservable, the opposite result holds.

The current paper analyzes the tradeoff between ex post selection and ex ante investment in a related environment in which investment is not directly observable. Boleslavsky and Cotton (2018) consider a game in which lobbyists design information structures to convince a policymaker to support a policy that they favor. Taylor and Yildirim (2011) consider a game in which an agent's unobserved effort and a principal's "selection standard" are determined simultaneously, showing that the principal can benefit from a policy of blind review, wherein the agent's cost is not observable. The literature on statistical discrimination is also related (Coate and Loury 1993). In this literature agents make unobservable investments but are evaluated based on a noise signal of their ex post performance. Because both effort and the evaluator's acceptance threshold are jointly determined in equilibrium, multiple equilibria can arise. Thus, identical agents may be treated differently in equilibrium. Crucially, in the current paper the noisy signal that is observed is not about ex post ability, rather it is about (relative) ex ante investment.

Finally, from a methodological perspective, the current paper is related to the literature on games with cyclical best responses, in particular, to the literature on complete information all-pay auctions (Hillman and Riley 1989, Baye, Kovenock and de Vries 1993, 1996). Although a university's payoff has a "winner take all" component—assuming that the evaluator is open-minded—our game in addition has a second component which is continuous and has a single interior peak. In the all-pay auction, the second component is typically strictly decreasing.

2. Model

Two universities and an evaluator play a two stage game. In the first stage, each university $i \in \{A, B\}$ simultaneously invests in its education quality $q_i \in [0, 1]$, which determines the distribution of its graduate's skill. Specifically, university i's graduate is high skill $(\tau_i = 1)$ with probability q_i and low skill $(\tau_i = 0)$ with probability $1 - q_i$. Each university's investment cost function is

$$\kappa(q_i) \equiv \frac{q_i^2}{4\alpha}.$$

Parameter α can be interpreted as a university's productivity, which is influenced by its resources, infrastructure, and student preparedness. To streamline the analysis, we focus on the case of $\alpha \leq 1/4$, which ensures that the upper bound $q_i \leq 1$ never binds in equilibrium. A university's education quality cannot be directly observed or verified by the evaluator. At the end of the first stage, each university produces a graduate who applies for the prize.

At the beginning of the second stage, the evaluator assesses the candidates. The evaluator is one of two types, $e \in \{M, P\}$. The universities are uncertain about the evaluator's type, and they believe that the evaluator is type M with probability μ. Both types of evaluator have the same objective, but each type observes different information during the review process. A *merit-based* evaluator (type M) learns the candidates' *true skills*, but a *prestige-based* evaluator (type P) observes a noisy signal that ranks *education quality* at each university. This signal, R, has two possible realizations, $r \in \{a, b\}$. The probability of each realization depends on relative quality, as illustrated in the following table:

	$\Pr(R = a)$	$\Pr(R = b)$
$q_A > q_B$	ρ	$1 - \rho$
$q_B > q_A$	$1 - \rho$	ρ
$q_A = q_B$	$1/2$	$1/2$

where $\rho \in (1/2, 1)$. Thus, realization $i \in \{a, b\}$ is more likely when university $I \in \{A, B\}$ has higher education quality, and both realizations are equally likely if quality is the same. Parameter ρ reflects the signal's informativeness. If $\rho = 1/2$, then the distribution of the signal does not depend on investment; it is pure noise. As ρ increases the signal is more likely to report the university whose quality is higher. If $\rho = 1$, then the signal perfectly reveals the higher quality university. The restriction $\rho \in (1/2, 1)$ implies that the public signal is informative but not fully revealing.

At the end of the second period, the evaluator awards the prize to one of the candidates. Both types of evaluator—and the organization that they represent—would like to award the prize to a high skill graduate. If she does so, then her payoff is one, and it is zero otherwise. Meanwhile, a university prefers that its graduate receives the prize, regardless of his or her skill. A university receives gross payoff one if its graduate is selected and zero otherwise. I focus on Perfect Bayesian Equilibrium throughout the paper.

Strategies. A mixed strategy for university $i \in \{A, B\}$ is random variable Q_i, distributed according to cdf $F_i(\cdot)$ over support $S_i \subseteq [0, 1]$. Because the type M evaluator observes each graduate's realized skill before assigning the prize, her strategy $m_i(\tau_A, \tau_B)$ specifies the probability with which she selects graduate $i \in \{A, B\}$, for each realization of graduate abilities $(\tau_A, \tau_B) \in \{0, 1\}^2$. Similarly, the type P evaluator observes the realization of R before assigning the prize. Therefore, her strategy $p_i(r)$ specifies the probability with which she selects graduate $i \in \{A, B\}$, for each signal realization $r \in \{a, b\}$.

Type M equilibrium strategy. A merit-based evaluator observes graduate skill before assigning the prize. Therefore, it is sequentially rational for her to select a high skill graduate over a low ability graduate and to randomize (with any probability) if both graduates are equally able. In keeping with the spirit of merit-based evaluation, I assume that type M randomizes fairly if she is indifferent. Thus, the type M evaluator's equilibrium strategy is

$$m_i(\tau_A, \tau_B) = \begin{cases} 1 & \text{if} \quad \tau_i > \tau_j \\ \frac{1}{2} & \text{if} \quad \tau_i = \tau_j \\ 0 & \text{if} \quad \tau_i < \tau_j. \end{cases} \tag{1}$$

Note that because the merit-based evaluator is perfectly informed, she always selects the best candidate. Thus, if education qualities were exogenous, then merit-based evaluation would dominate any other strategy for evaluating candidates and assigning the prize.

Type P equilibrium strategy. Combined with the university's investment strategies, a prestige-based evaluator uses signal R to update her beliefs about candidate ability.

Given university i's investment strategy Q_i and signal realization r, type P's expected payoff from selecting candidate i is

$$v_i(r) \equiv \Pr(\tau_i = 1 | R = r) = E[Q_i | R = r], \tag{2}$$

where the equality follows from the Law of Total Probability.[1] Therefore it is sequentially rational for the evaluator to select the graduate of the university that she believes has higher expected quality, accounting for the universities' investment strategies and the signal realization. If she believes that both universities have the same expected quality, then she is willing to randomize. In this case, I assume that she assigns the prize to candidate i with probability ϕ_i, where $\phi_A + \phi_B = 1$. Thus, the type P evaluator's equilibrium strategy is

$$p_i(r) = \begin{cases} 1 & \text{if} \quad v_i(r) > v_j(r) \\ \phi_i & \text{if} \quad v_i(r) = v_j(r) \\ 0 & \text{if} \quad v_i(r) < v_j(r). \end{cases} \tag{3}$$

Open-Minded and Closed-Minded Strategies. In general, the universities' strategies and the public signal jointly determine the type P evaluator's selection. In particular, the universities (mixed) investment strategies determine her prior beliefs about the expected skill level of each university's graduate, which is refined further by the public signal. The prestige-based evaluator then selects the graduate who is expected to have a higher average skill. However, it could be that, given the universities' investment strategies, the type P evaluator has a strong prior over relative investment (and relative graduate quality), and the public signal realization is insufficiently informative to affect her selection.[2] In this case, the type P evaluator's strategy is *closed-minded*, since the evaluator does not adjust her selection in response to the public signal. In contrast, it could be that the type P evaluator responds to the public signal, selecting the graduate of the university that is reported to have invested more. In this case, the type P evaluator's strategy is *open-minded*, since she follows the realization of the public signal.[3] Formally,

Definition 1. *The type P evaluator's strategy is (i) closed-minded if $p_i(a) = p_i(b) = p_i$, (ii) open-minded if $p_i(i) = 1$ and $p_i(j) = 0$.*

In the analysis, I focus on equilibria in which the type P evaluator's strategy is closed-minded or open-minded. Given the type P evaluator's tie-breaking rule, equilibria in which type P's strategy is neither closed-minded nor open-minded exist only in a knife-edge case.[4] We refer to an equilibrium in which the type P evaluator plays a closed-minded (open-minded) strategy as a "closed-minded" ("open-minded") equilibrium.

[1] $\Pr(\tau_i = 1 | R = r) = E[\Pr(\tau_i = 1 | R = r, Q_i)] = E[Q_i | R = r]$.

[2] For example, it could be that her prior belief favors one graduate so strongly that even an unfavorable signal realization is insufficiently informative to alter her selection. Similarly, it could be that under the prior belief, the evaluator is certain that both universities invested exactly the same amount.

[3] Because $\rho \in (1/2, 1)$, the university that is reported by the signal is (weakly) more-likely to have a higher relative investment. Thus, it cannot be that the type P evaluator always selects the graduate of the university that is not reported by the public signal.

[4] It is possible that $p_i(i) > p_i(j)$ and $p_i(i) < 1$. In this case, the type P evaluator responds to the public signal, without always selecting the corresponding graduate. Such a strategy requires the type P evaluator

Universities' Interim Expected Payoffs. Each university obtains gross benefit 1 whenever its graduate is selected, and it must pay the cost of its education quality q_i. Ex post, the probability of being selected by a merit-based evaluator is given in (1). Before the skill levels are realized, the probability that graduate i is selected by a merit based evaluator when investments are (q_A, q_B) is

$$E[m_i(\tau_A, \tau_B)] = \frac{1}{2}\{q_i q_j + (1-q_i)(1-q_j)\} + q_i(1-q_j) = \frac{1}{2}(1 + q_i - q_j).$$

Thus, graduate i is selected with probability $1/2$ whenever both graduates have the same realized skill and with probability 1 when graduate i has high skill and graduate j has low skill. Meanwhile, given realized investments (q_A, q_B), the probability that graduate i is selected by the prestige-based evaluator is

$$E[p_i(r)|q_A, q_B] = \Pr(R = i|q_A, q_B)p_i(i) + \Pr(R = j|q_A, q_B)p_i(j),$$

where the expectation is taken with respect to the realization of the public signal. In turn, note that, with this signal structure we have,

$$\Pr(R = i|q_A, q_B) = \mathcal{I}(q_i > q_j)\rho + \frac{1}{2}\mathcal{I}(q_A = q_B) + \mathcal{I}(q_i < q_j)(1-\rho).$$

Given that the probability of a merit-based evaluator is μ, university i's expected payoff when the investments are (q_A, q_B) is

$$u_i(q_A, q_B) = \mu E[m_i(\tau_A, \tau_B)] + (1-\mu)E[p_i(r)|q_A, q_B] - \kappa(q_i). \tag{4}$$

3. Analysis

In this section, we analyze the model and characterize the unique closed-minded and open-minded equilibrium respectively. Before doing so, we present two simple sufficient conditions that guarantee that the type P evaluator plays a closed-minded or open-minded strategy in equilibrium.

Lemma 1. *If the universities play pure strategies, then the type P evaluator's unique best response is the closed-minded strategy. If the universities play identical, continuous, non-degenerate mixed strategies, then the type P evaluator's unique best response is the open-minded strategy.*

In general, the universities' strategies and the public signal jointly determine the prestige-based evaluator's selection: the universities (mixed) investment strategies determine her prior beliefs about each graduate's skill, which is refined further by the public signal. However, in the two cases highlighted in this result, one of these channels is absent. If the prestige-based evaluator anticipates that the universities play pure strategies, then the realization of the signal is irrelevant—the evaluator's prior belief allows her to rank the investments with certainty, and any signal realization that disagrees with her prior belief can be plausibly attributed to noise. In contrast, if the universities

to be indifferent when the signal realization is i, and the evaluator's strategy is pinned down by her tie-breaking rule, restricting the degrees of freedom in the analysis. It is possible to construct the incentives for the universities to mix appropriately to justify such updated beliefs only for a knife edge case of (ρ, α).

play identical mixed strategies, then the evaluator's prior belief is that expected education quality at each school is identical, and each school is equally likely to have invested more than the other. Because the public signal is informative about relative investment, the realization conveys good news about relative investment, breaking the type P evaluator's indifference. In this circumstance, it is strictly optimal for the prestige-based evaluator to select the graduate by following the public signal.

3.1. **Closed-Minded Equilibrium.** We begin our equilibrium characterization by considering the closed-minded equilibrium first. In this case, the type P evaluator selects graduates independently of the public signal, $p_i(r) = p_i$. Thus, universities' interim payoffs (4) are

$$\begin{aligned} u_i(q_A, q_B) &= \mu E[m_i(\tau_A, \tau_B)] + (1-\mu)p_i - \kappa(q_i) \\ &= \frac{\mu}{2}(1 + q_i - q_j) + (1-\mu)p_i - \frac{1}{4\alpha}q_i^2. \end{aligned}$$

Considering each university's best response, note that the first order condition has a unique solution $q_i = \alpha\mu$, and this solution is within the unit interval. Furthermore, the interim payoff is concave in university i's strategy. By implication, when the type P evaluator is expected to play a closed-minded strategy, it is optimal for the universities to play pure strategies. From Lemma 1, the closed-minded strategy is indeed optimal for the type P evaluator in this case. Combining these observations we have the following result.

Proposition 1. *(Closed-Minded Equilibrium.) A closed-minded equilibrium exists. Each university selects investment $q_i = q_c \equiv \alpha\mu$. The type P evaluator's belief is $v_i(r) = \alpha\mu$ and $p_i(r) = \phi_i$, regardless of the public signal realization. No other closed-minded equilibrium exists.*

Intuitively, whenever the prestige-based evaluator plays a closed-minded strategy, a university's investment has no effect on her selection decision. Thus, the incentive to invest solely arises from the decision of the merit-based type. Because the merit-based type *knows* the realized skill levels of the graduates and selects the best one, each university's benefit is continuous (in fact, linear) in its investment level. With a continuous, convex cost, the resulting equilibrium is in pure strategies, justifying the type P evaluator's closed-minded strategy.

The previous observation also suggests that the equilibrium level of investment increases with μ, the probability of the merit-based type. Indeed, in a closed-minded equilibrium, the expected benefit of investment only arises from the selection decision of this type of evaluator. The higher the probability of encountering a merit-based type, the higher the marginal benefit of investment, resulting in a higher overall equilibrium investment level for each university. By implication, the organization's ex ante payoff is also higher when the probability of the merit-based type increases. Indeed, an increase in μ has the direct benefit of increasing the probability of the type M evaluator, who always selects the best graduate ex post, rather than selecting a random graduate as the type P evaluator does. It also generates an indirect benefit by increasing investment, so that each graduate is more likely to have high skill. In the closed-minded equilibrium, both the direct and indirect effect of increases in the probability of the merit-based evaluator work together to increase the evaluator's equilibrium payoff. Building on these observations, we prove the following result.

Proposition 2. *(Effect of μ in Closed-Minded Eq.) In the closed-minded equilibrium, the expected skill of each graduate and the organization's expected payoff are increasing in μ.*

Proposition 2 captures the "conventional wisdom" of prestige-based evaluation. In a closed-minded equilibrium the type P evaluator selects graduate i with probability ϕ_i, regardless of the merits of the individual candidate and the information about relative education quality inherent in the public signal (ranking). This not only makes it less likely that the highest skill graduate is selected for the prize, but it also weakens the incentive to invest in education, reducing the overall probability that a high skill graduate is produced by either school. An increase in the probability of a merit-based evaluation, not only may appear more "fair," but it is also beneficial for the organization.

3.2. **Open-Minded Equilibrium.** Now consider a possible open-minded equilibrium. In such an equilibrium, the type P evaluator follows the public signal so that $p_i(i) = 1$ and $p_j(i) = 0$. Defining $\beta \equiv \rho - 1/2 > 0$, each university's interim payoff is

$$u_i(q_A, q_B) = \mu E[m_i(\tau_A, \tau_B)] + (1-\mu)\{\mathcal{I}(q_i > q_j)\rho + \frac{1}{2}\mathcal{I}(q_i = q_j) + \mathcal{I}(q_i < q_j)(1-\rho)\} - \kappa(q_i).$$
$$= \underbrace{\frac{\mu}{2}\{1 + q_i - q_j\} + (1-\mu)\frac{1}{2} - \frac{1}{4\alpha}q_i^2}_{\text{closed-minded component}} + (1-\mu)\underbrace{\beta\{\mathcal{I}(q_i > q_j) - \mathcal{I}(q_i < q_j)\}}_{\text{open-minded component}}.$$

Each university's interim payoff can be decomposed into two parts. The first component is the university's interim payoff with a closed-minded evaluator and a fair tie-breaking rule. The second component captures the effect of the evaluator's open-minded strategy. If both schools choose identical investments, then the pubic signal is equally likely to realize and each graduate is equally likely to be selected. If one school increases its investment slightly, then the probability that the public signal realizes in its favor and its graduate is selected jumps to $\rho > \frac{1}{2}$. In essence, when investment differs across universities, the evaluator's open-minded strategy transfers "bonus" $\beta > 0$ from the university that invested less to the university that invested more.

The tradeoff between the two components of its payoff shapes a university's incentive to invest. The closed-minded component is continuous, concave and has a single peak at $q_i = q_c$. Meanwhile, the open-minded component is a step function, with value $-\beta$ for $q_i < q_j$, zero at $q_i = q_j$, and β for $q_i > q_j$. Thus, it is weakly increasing and discontinuous at $q_i = q_j$. By implication, for $q_i < q_c$, an increase in q_i strictly increases the closed-minded component (moving closer to its peak) and weakly increases the open-minded component. In other words, for $q_i < q_c$, there is no conflict between the two components of the university's interim payoff. Thus, investment levels $q_i < q_c$ are strictly dominated by q_c. In contrast, for $q_i > q_c$ the two components conflict. In order to collect bonus b in the open-minded component, university i must select $q_i > q_j \geq q_c$, thereby pushing its investment past the peak of the closed-minded component. Doing so is worthwhile only if it does not have to push its investment *too far* past the peak q_c in order to capture the bonus. Otherwise it is better to "pay" the bonus to the other university, but optimize the closed-minded payoff by selecting q_c.

To explore this tradeoff further, suppose that the components conflict: university i wins the open-minded component by investing $q_i > q_c$ and loses it by investing q_c (i.e., $q_j \in (q_c, q_i)$). Even though it has to pay the bonus, it may nevertheless be in university

i's interest to invest q_c, since optimizing the closed-minded component may outweigh the loss in the open-minded component. Focusing on $q_i > q_c$, consider the following inequality,

$$\begin{gathered} u_i(q_c, q_j) > u_i(q_i, q_j) \Rightarrow \\ \frac{\mu}{2} q_c - \frac{1}{4\alpha} q_c^2 - (1-\mu)\beta > \frac{\mu}{2} q_i - \frac{1}{4\alpha} q_i^2 + (1-\mu)\beta \Rightarrow \\ q_i > \bar{q} \equiv q_c + s, \\ s \equiv 2\sqrt{2\alpha(1-\mu)\beta}. \end{gathered} \tag{5}$$

Thus, even if an investment of q_i wins the bonus and q_c loses it, investment levels $q_i > \bar{q}$ are strictly worse than q_c.[5] In other words, $q_i > \bar{q}$ are strictly dominated by q_c. This calculation also implies that when $q_i \leq \bar{q}$, a university would rather win the bonus with investment q_i than lose it with investment q_c.

Examining a university's best response in more depth provides insight into the structure of the equilibrium strategies. When responding to any $q_j \in (q_c, \bar{q})$ university i has two options. If it chose to do so, a university could give up the bonus by choosing $q_i < q_j$. Since such a choice loses the open-minded component, it is best to optimize the closed-minded component by selecting $q_i = q_c$. On the other hand, it could try to capture the bonus by choosing $q_i > q_j$.[6] Among these, it would like to select q_i as close as possible to the peak, ideally "just above" q_j. Thus, a university can either "leap-frog" its rival, winning the bonus with an investment just above q_j, or it can select q_c and pay the bonus to its rival. When $q_j < \bar{q}$, the calculation in (5) tells us that university i would rather leap-frog its rival. Conversely, at $q_j = \bar{q}$, a leap-frog requires an investment above $\bar{q}$. From (5), university i's best response in this case is $q_i = q_c$.

Together, the preceding observations suggest that iterated best responses have a cyclical structure. Starting from $q = q_c$, each university best responds with a leap-frog until the investment level reaches $\bar{q}$, at which the leap-frog is no longer beneficial. Once this investment level is reached, the best response is q_c, restarting the cycle. Arguments from the literature on complete information all-pay auctions, which also feature cyclical best responses, can be adapted to characterize the equilibrium structure.

Lemma 2. *If an open-minded equilibrium exists, then each university plays an identically distributed mixed strategy with no mass points or gaps, supported on interval* $[q_c, \bar{q}]$.

To derive a university's mixed investment strategy, we use the standard indifference condition, which requires that every investment level inside the support of its mixed

[5] Consider the function in the second line of (5). Note that with $\alpha < 1/4$, RHS is negative at $q_i = 1$, while left hand side is strictly positive. Because RHS is decreasing in its first argument, and equality is attained at $\bar{q}$, it follows that $\bar{q} < 1$.

[6] Note that matching its rivals choice does not allow university i to capture the bonus, and an arbitrarily small increase in its investment would have a negligible effect on the closed-minded component, but would increase the open-minded component from 0 to b. Therefore, matching the other university's investment is never a best response.

strategy generates the same expected payoff. In particular, the following proposition establishes that a unique mixed strategy is implied by Lemma 2 and a university's indifference condition. Because both universities use the same non-degenerate mixed strategy, Lemma 1 implies that the open-minded strategy is the type P evaluator's best response.

Proposition 3. *(Open-Minded Equilibrium.) An open minded equilibrium exists. Each university's mixed strategy Q_i is identically distributed with distribution function*

$$F(q) = \frac{(q - q_c)^2}{s^2},$$

supported on interval $[q_c, \bar{q}]$. The type P evaluator's belief has $v_i(i) > E[Q_i] > v_i(j)$ and $p_i(i) = 1$, $p_i(j) = 0$. No other open-minded equilibrium exists.

The (convex) quadratic shape of the equilibrium distribution function is a consequence of the (concave) quadratic shape of the closed-minded component of the interim payoff. As a university increases its investment above q_c, it moves further from the peak of the closed-minded component. The payoff cost of such an increase is the drop in the closed-minded payoff component—this cost is (convex) and quadratic. In order to satisfy the university's indifference condition, the additional probability of winning the open-minded component must offset this cost, and thus it also must be a (convex) quadratic. By implication, probability mass is concentrated closer to the top of the support rather than the bottom and expected investment is closer to the top of the support than the bottom.

As the probability of the merit-based type increases, universities' incentives to invest are affected by countervailing forces. With a higher probability of a merit-based evaluation, the weight on the selection decision of the merit-based type in a university's payoff increases. Thus, the marginal benefit of investment in the closed-minded component increases, which in turn increases q_c, the bottom of the support of the equilibrium mixing distribution. On the other hand, the weight on the open-minded component decreases, weakening the incentive to leap-frog the other university's investment, reducing the "spread" of the equilibrium mixing distribution, $s = \bar{q} - q_c = 2\sqrt{2\beta(1-\mu)}$. The total effect on the top of the support, $\bar{q}$, is ambiguous: q_c increases with μ but s decreases. Because the probability mass is concentrated near $\bar{q}$, the consequences for expected investment are also ambiguous. The effect of μ on expected equilibrium investment is characterized in the following proposition.

Proposition 4. *(Open-minded eq., effect of μ on investment). A threshold $\mu^*(\alpha, \beta) \in [0, 1)$ exists, such that $E[Q_i]$ is strictly decreasing in μ if and only if $\mu > \mu^*(\alpha, \beta)$.*

Though expected invested may be increasing for small values of μ, for values of $\mu > \mu^* \in [0, 1)$, expected investment is strictly decreasing. In other words, when the probability of a merit-based evaluator is sufficiently large, further increases in this probability dampen the incentive to leap-frog enough to outweigh the upward shift of the bottom of the support, reducing expected equilibrium investment.

Proposition 4 suggests that an increase in the probability of a merit-based evaluation generates a normative tradeoff for the organization. On one hand, an increase in μ is beneficial to the organization, since the merit-based evaluator always selects the optimal graduate ex post, while the prestige-based evaluator, who selects a graduate solely based on a noisy signal of relative investment, sometimes selects a low skill graduate by mistake. On the other hand, when $\mu > \mu^*$, additional increases in μ reduce expected investment by each university, reducing the probability that either graduate has high skill in the first place. The next proposition shows that the dampened incentive to invest outweighs the benefits from the selection of high skill graduates when μ is high—conducting exclusively merit-based evaluations is suboptimal for the organization.[7]

Proposition 5. *(Open-minded eq., effect of μ on organization). A threshold $\mu^{**}(\alpha, \beta) < 1$ exists, such that the organization's payoff in the open-minded equilibrium is strictly decreasing for $\mu > \mu^{**}(\alpha, \beta)$.*

Together, Propositions 4 and 5 reveal an aspect of prestige-based evaluation that is missing from the conventional wisdom. Provided that the prestige-based evaluator is "open-minded" when responding to public information about universities educational investments, such evaluations incentivize investments in education and increase the probability that a high skill graduate is selected.

4. Conclusion

This paper develops a simple model of an evaluation process featuring merit-based and prestige-based evaluations and endogenous investment in education, showing that when the prestige-based evaluator is open-minded in his or her view of "prestige" an increase in the probability of a prestige-based evaluation increases expected equilibrium investment and the organization's payoff. Crucially, the type P evaluator must adjust his or her view of which school is more prestigious (delivers higher education quality) in response to the public signal. If not, the conclusions are reversed. While some existing evidence suggests that elite evaluator's perceptions of prestige are slow to change and are tied loosely to rankings, whether this link is strong enough to generate the effect identified in this paper is ultimately an empirical question. Furthermore, the analysis suggests that if prestige-based evaluators could be persuaded to be more open-minded in the formation of prestige, their organizations would benefit.

[7] At the other extreme, it is possible to show that purely prestige-based evaluations ($\mu = 0$) are also sub-optimal if the informativeness of the public signal is not too small.

Appendix A. Proofs

Proof of Lemma 1. If both universities play pure strategies, then $v_i(r) = q_i$, because q_i is deterministic. That the closed-minded strategy is type P's best response is immediate. If each university plays an identical, continuous mixed strategy $Q_i \sim F(\cdot)$, note that the conditional density of Q_i given $R = i$ is

$$f_i(q|R = i) = f(q)\frac{\rho \Pr(Q_j < q) + (1-\rho)\Pr(Q_j > q)}{\int_0^\infty \{\rho \Pr(Q_j < q) + (1-\rho)\Pr(Q_j > q)\} f(q)dq}$$

$$f_i(q|R = i) = f(q)\frac{\rho F(q) + (1-\rho)(1 - F(q)}{\int_0^\infty \{\rho F(s) + (1-\rho)(1 - F(s))\} f(s)ds}.$$

Note that $f(\cdot)$ and $f(q|R = i)$ have the same support. Within the support, consider the likelihood ratio

$$\frac{f_i(q|R = i)}{f(q)} = \frac{\rho F(q) + (1-\rho)(1 - F(q))}{\Pr(R = i)}.$$

Note that

$$\frac{d}{dq}\frac{f_i(q|R = i)}{f(q)} = \frac{(2\rho - 1) f(q)}{\Pr(R = i)} > 0,$$

because $\rho > 1/2$. It follows that the likelihood ratio is monotone inside the common support, which implies that $Q_i|R = i$ first order stochastic dominates Q_i, and hence $E[Q_i|R = i] > E[Q_i]$. □

Proof of Proposition 2. That q_c increases in μ is obvious. Note that the evaluator's expected payoff is

$$v(q_c(\mu)) = \mu(2q_c - q_c^2) + (1-\mu)q_c = \mu(q_c - q_c^2) + q_c.$$

Indeed, each graduate has high skill with probability q_c. If the evaluator is merit-based, then she receives payoff 1 whenever at least one graduate has high skill and otherwise 0. If she is prestige-based, then she is indifferent between graduates and receives payoff 1whenever her randomly chosen graduate has high skill and otherwise 0.

Differentiating with respect to μ, we have

$$\frac{d}{d\mu} v(q_c(\mu)) = q_c - q_c^2 + (1 + \mu(1 - 2q_c))\frac{dq_c}{d\mu}.$$

Note that $q_c \in (0, 1)$ and hence $q_c - q_c^2 > 0$ and $1 + \mu(1 - 2q_c) > 1 - \mu \geq 0$ and $dq_c/d\mu > 0$. The result is immediate. □

Proof of Proposition 3. University i's indifference condition inside the support of its mixed strategy requires

$$q_i \in (q_c, \bar{q}) \Rightarrow E[u_i(q_i.Q_j)] = u_i^*.$$

for some constant u_i^*. Substituting and isolating the terms that depend on q_i, we have

$$\frac{\mu}{2} q_i - \frac{1}{4\alpha} q_i^2 + 2(1-\mu)\beta F(q_i) = v_i^*,$$

where v_i^* is constant, different from u_i^*. Solving for $F(q_i)$ and using the condition $F(q_c) = 0$, we have

$$F(q_i) = \frac{(q - q_c)^2}{s^2}.$$

Note that $\bar{q} - q_c = s$, and hence the condition $F(\bar{q}) = 1$ is automatically satisfied. Thus the indifference condition and boundary condition $F(q_c) = 0$ characterize a unique mixed strategy. From Lemma 1 it is optimal for the type P evaluator to use an open-minded strategy, completing the characterization. □

Observation 1. Let x be a positive number and allow $\mu \in (-\infty, 1)$. Define $G_x(\mu) \equiv \alpha\mu + 2x\sqrt{2\beta\alpha(1-\mu)}$, and note the following,

$$\frac{dG_x}{d\mu} = \alpha - \frac{x}{1-\mu}\sqrt{2\beta\alpha(1-\mu)}, \tag{6}$$

and hence,

$$\frac{dG_x}{d\mu} = 0 \Rightarrow \mu = 1 - \frac{2\beta x^2}{\alpha} < 1.$$

Hence, function G has a single critical point, and this critical point is less than 1. Using L'hospital's rule, it is straightforward to show that as $\mu \to 1$ the derivative in (6) approaches $-\infty$. Thus, G has a unique critical point $1 - bx^2/(2\alpha)$, which is its global maximum. Furthermore,

$$\lim_{\mu \to 1} \frac{dG_x}{d\mu} = -\infty.$$

Proof of Proposition 4. Note that the density of the equilibrium mixed strategy is $f(q) = 2(q - q_c)/s$, and hence,

$$E[Q_i] = \int_{q_c}^{q_c+s} q[\frac{2(q-q_c)}{s^2}]dq = q_c + \frac{2}{3}s.$$

Next, note that $E[Q_i] = G(\mu)$ with $x = 2/3$, with domain $[0,1]$. From Observation 1, $E[Q_i]$ is decreasing in μ for all $\mu > \mu^* \equiv \max\{0, 1 - 8\beta/(9\alpha)\}$. □

Proof of Proposition 5. First, consider the organization's payoff function. If the evaluator is type M, the organization's expected payoff is

$$E[Q_A + Q_B - Q_A Q_B] = 2E[Q_i] - E[Q_i]^2.$$

Note that

$$E[Q_i] = \int_{q_c}^{\bar{q}} q\Big(\frac{2(q-q_c)}{s^2}\Big)dq = q_c + \frac{2}{3}s.$$

If the evaluator is type P, then the organization's payoff is

$$\rho E[\max\{Q_A, Q_B\}] + (1-\rho)E[\min\{Q_A, Q_B\}].$$

Using standard formulas for order statistics, we have

$$E[\max\{Q_A, Q_B\}] = \int_{q_c}^{\bar{q}} 2q\Big(\frac{2(q-q_c)}{s^2}\Big)\Big(\frac{(q-q_c)^2}{s^2}\Big)dq = q_c + \frac{4}{5}s$$

$$E[\min\{Q_A, Q_B\}] = \int_{q_c}^{\bar{q}} 2q\Big(\frac{2(q-q_c)}{s^2}\Big)\Big(1-\frac{(q-q_c)^2}{s^2}\Big)dq = q_c + \frac{8}{15}s$$

Substituting and simplifying, with a type P evaluator the organization's payoff is

$$q_c + \frac{2}{3}s + \frac{4}{15}\beta s = E[Q_i] + \frac{4}{15}\beta s.$$

The organization's expected payoff is therefore,

$$\mu\Big(2E[Q_i] - E[Q_i]^2\Big) + (1-\mu)(E[Q_i] + \frac{4}{15}\beta s).$$

Differentiating, we have

$$\Big(2E[Q_i] - E[Q_i]^2\Big) - \Big(E[Q_i] + \frac{4}{15}\beta s\Big) +$$
$$2\mu\frac{dE[Q_i]}{d\mu}(1 - E[Q_i]) + (1-\mu)(\frac{dE[Q_i]}{d\mu} + \frac{4}{15}\beta\frac{ds}{d\mu}).$$

Note first that this derivative is continuous in μ for $\mu \in (0,1)$. Next, note that the first line is the difference in expected payoffs from a type M and P evaluator, and is therefore bounded between 0 and 1. Next, note that $dE[Q_i]/d\mu = dG_{2/3}/d\mu \to -\infty$ as $\mu \to 1$ and $E[Q_i] < 1$. Finally, note that $ds/d\mu \to -\infty$ as $\mu \to 1$. Therefore, the derivative of the organization's expected payoff approaches $-\infty$ as $\mu \to 1$. By continuity, exists some $\mu^{**}(\alpha,\beta) < 1$ such that the organization's payoff is decreasing for $\mu \in (\mu^{**}, 1)$. □

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