A TALE OF TWO TRACKS

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Abstract

We provide a simple framework that helps explore the need for contingent (teaching) jobs in academia alongside the usual tenured-professorship positions. It also explains the coexistence of these two types of jobs in research universities as an equilibrium phenomenon. Imprecisions in the academic editorial process, combined with the increasing difficulty of producing academic research, is suggested as a possible explanation for the recent increasing trend in the share of non-tenure-track teaching jobs in academia as well as the widening wage gap between tenured-professors and teaching faculty. Alternative interpretations are explored.

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1 Introduction

Most jobs in academia are currently non-tenure-track positions. Tenured and tenure-track jobs in American universities and colleges constituted the majority (57%) of the academic labor force in 1975. That percentage dropped to 42% in 1995, and further decreased to a mere 34% in 2015 (AAUP 2017). This is the result of a long-lasting increasing trend in the number of non-tenure-track teaching jobs at the expense of tenure-track and tenured jobs (Zhang, Ehrenberg, and Liu 2015; Ehrenberg 2004; Kasper 1986).

Ample literature has addressed the need for the tenure system in academia, for reasons such as obtaining academic freedom, facilitating risky projects, increasing teaching productivity, increasing tuition revenues, and offering incentives for hiring the best candidates (Carmichael 1988; Cater, Lew, and Smith 2008; Bhagwati and O'Flaherty 2001; Brogaard, Engelberg, and Van Wesp 2018; Cater, Lew, and Pivato 2017), while other recent studies pointed to the possible optimality of non-tenure-track contracts in academia under some circumstances (Popov 2015; Kimmitt 2009; Chen and Lee 2009).

Cater, Lew, and Pivato (2017) provided theoretical explanation supporting the tenure contract in academia, but also reconciling many of the stylized facts about the tenure system that have never been collectively addressed in any single study. They also pointed out the possibility of universities increasingly making use of non-tenure-track contracts instead—due to the decaying research impact, the standardized undergraduate teaching, the shift away from research-oriented disciplines and toward applied and vocational programs, and the uncertainty with regards to future market conditions and thus future long-term tuition revenues.

This study develops a simple efficiency-wage model which provides explanations to the coexistence of teaching faculty and research faculty in equilibrium. The model is based on the asymmetry of information regarding the research effort that academics exert to produce publishable research.[1] Beyond the obvious, voiced reason of budget flexibility provided by the employment of contingent faculty (AAUP 1992), this study also shows that the teaching track (teachers) is an inherent part of the academic workforce, alongside the research track (tenured professors). By tying the tenure system to the academic publishing enterprise, this study suggests that the trend of substituting contingent teachers for permanent professors is not indefinite—in the steady state, both teachers and professors will constitute a non-trivial share of the academic labor force.[2]

The study also provides a framework that, utilizing publicly available information about

[1] Although successes in "star" jobs are rare and easier to observe (Baron and Kreps 1999), akin to research publications for academics, the efforts invested to produce such successes are unobservable. Additionally and probably equally importantly, a long period between investment of the effort and verification of the results is required (Ellison 2002).

[2] This addresses concerns regarding the eroding role and status of the tenure system in academia: "For higher education as a whole, the growing use of non-tenure-track faculty members, part-time and full-time, undercuts the tenure system, severs the connection between control of the curriculum and the faculty who teach it, and diminishes the professional status of all faculty members." (AAUP 1992, p.39).

academia, can be applied to understand the observed changes and trends in the academic labor market. For example, the diminishing share of tenured and tenure-track faculty in academia, combined with the increasing instructor-professor wage gap, is explained by the recently observed declining trends in the acceptance rates of papers for publication in journals of nearly all fields of science,[3] and potentially the increasing difficulty in conducting research. Higher imprecision in the editorial process makes it more costly for researchers to publish their papers, and thus more costly to secure a tenured-professor position. Consequently, a higher wage would have to be paid for tenured professors, and less of them would be hired.

The model also offers ways to understand the link between the observed declining acceptance rates, the potential increase in the imprecision of the editorial process, and the relatively newly introduced method of initial screening of papers before sending them for review by outside experts (a procedure known as summary rejection, desk rejection, immediate rejection, or bench rejection).

We explore different extensions and limitations of the model. First, we consider different interpretation of the model implications, such as the tenure system affecting the publication enterprise rather than, or in addition to, being affected by it. Second, we relate to the issue of the increasing number of authors per paper and its relationship with research effort. Finally, we suggest different extensions to the model, by relaxing the assumption of homogeneous

[3] As outlined in Aarssen (2012) for ecology, this decline is only motivated by the interest to elevate the status of the journal by increasing its impact factor and competing with other journals for that status. Supportive evidence comes from different fields: for example, Wardle (2012) for ecology, Conley (2012) for economics, Nature Editorial (2012) for Nature, DiPiro (2013) for pharmaceutical studies, and the American Psychological Association (2017) for psychology, among others.

academic labor force, or by relaxing the assumption of fixed-size academic labor force; and we explore their implications on the main predictions of the model.

The study proceeds as follows. The following section outlines the simple model which describes the population of academics, their production function, the determination of their effort, and characterizes the academic labor market equilibrium. Section 3 provides basic simulations of the comparative statics of the model, calibration of the model parameters, and explores some extensions. Section 4 discusses qualifications and alternative interpretations of the model. Section 5 concludes.

2 The Model

In the spirit of Shapiro and Stiglitz (1984), we build a simple efficiency-wage model that applies to the academic labor market. First we describe the academic labor force and the derived demand for professors; then we outline the academic publication process, and build the effort-determination conditions; and finally we characterize the resulting equilibrium and derive basic comparative statics.

2.1 Academic Personnel and the University

New graduates are assumed to join the academic labor market on a tenure-track contract. They stay in this position only one period during which they exert effort, e, and need to succeed. For simplicity, we assume that e is dichotomous: can be either zero, or positive $e > 0$.[4]

If the individual succeeds, she moves to the "tenured class," and becomes a tenured professor whose wage is w_P. Otherwise, she becomes a teacher, whose wage is w_T. We assume that it is prohibitive for teachers to become tenured professors.[5]

The university determines success by setting the needed number of published papers in a representative journal of the field. Without loss of generality, we assume that only one published paper is required for success. The production function of the university is given by $f(P_i, T_i)$, where P_i is the number of tenured professors in university i and T_i is the number of teachers in university i. There are N identical universities such that $P = \sum_{i=1}^{N} P_i$ and $T = \sum_{i=1}^{N} T_i$. The aggregate production function, $F(P,T) = \sum_{i=1}^{N} f(P_i, T_i)$, is given by:

$$F(P,T) = w_T \times (P + T) + g(P)$$

where $g(P)$ signifies the added productivity of tenured professors.[6] $g(0) = 0$, $g'(P) > 0$,

[4]Considering effort as a continuous variable does not impact the qualitative results of the model.

[5]Although realistic, this is only a simplifying assumption. Relaxing it does not qualitatively change the results in this study. The case where teachers can become tenured professors, and tenured professors can be dismissed, was considered in a previous version of this study (Asali 2018).

[6]The literature is not unanimous as to the effect of tenure on the quality of teaching. Some studies show that there is zero correlation between the quality of teaching and the performance of research (Hattie and Marsh, 1996, 2004), while others find that the increase in the share of non-tenure-track faculty at American universities has adversely affected the graduation rates of undergraduate students (Ehrenberg and Zhang, 2005). Other studies have attributed the improved learning outcomes of undergraduates in their first term to teaching by contingent (non-tenure-track) faculty in contrast to tenure-track or tenured faculty (Figlio, Schapiro, and Soter, 2015). Yet other studies find that teaching productivity—the university's benefit from such teaching—is positively associated with a good research record (Cater, Lew, and Smith 2008).

and $g''(P) < 0$. Academics are assumed to be risk neutral. In particular, researchers and teachers have the following linear utility function: $U = w - e$, where w is the net wage (earnings net of any observable effort) and e is the *unobservable* research effort.

Teaching involves only observable effort; however, successful research necessitates some unobserved amount of effort, $e > 0$. We assume that the marginal productivity of professors is always higher than $w_T + e$ (which essentially imposes the condition that $g'(P) > e$ for any P). That is, in full information (when e is observable) academics always prefer the tenured professor position over the teaching position.

2.2 The Publication Process

Writing working papers is a verifiable action; hence, it is performed by all academic (tenure-track) researchers. The research effort invested in writing a paper, however, is not verifiable by the department. Working papers produced without effort are considered low-quality research (hereafter "bad papers"). Only working papers produced with effort are considered high-quality research ("good papers").

An indication of the research effort, e, is gleaned from the publication process. Essentially, the university is choosing to "outsource" the task of evaluating the working papers (and inferring the invested effort therein) to academic journals.[7]

[7] In Professor Solow's words: "... promotion and tenure decisions often turn, for better or worse, on who published how many articles in which journals. This saves senior members the trouble of actually reading the articles." (Solow 2014)

Universities, alternatively, can themselves evaluate working papers and determine the invested effort ("in-house"). However, given that in reality it is not generally the case, it is likely that universities do not find

To become a tenured professor, a researcher must secure publication of her paper in a representative journal.[8] The probability of rejecting a paper is higher for bad papers than for good papers. In particular, the editor is assumed to have some ability to discern good papers from bad papers. The editor can summarily ("Desk-Reject") a paper, or she can forward it to reviewers who will either reject or accept the paper.

The null hypothesis being $e > 0$ (the submitted paper is a good paper), a "type I error" by the editor would be: $\Pr(\text{Desk Reject } |e > 0) = \alpha$, and a type-II error would be *not* to reject a bad paper: $\Pr(\text{NOT Desk Reject } |e = 0) = \beta$. The "power" of the test would be the probability to desk-reject a bad paper: $\Pr(\text{Desk Reject } |e = 0) = 1 - \beta$.

Naturally, the probability of rejecting a bad paper should be higher than the probability of rejecting a good paper, $1 - \beta > \alpha$.

If the editor does not desk-reject the paper, she forwards it to reviewers for additional evaluation. Upon receiving a paper for evaluation from the editor, the referees can reject or accept it with the following probabilities, assuming that the probability of rejecting a bad

this process cost-effective. Yet, where the tenure-track contract is optimal, the perceived cost of internal evaluation of research and faculty effort is likely overestimated; and it is not clear whether this cost is outweighed by the cost of deviating from a tenure-track contract.

[8]For simplicity, we assume there is a single good journal in the profession in which the publication of research matters to the department. Using the terminology of Baghestanian and Popov (2018), this is the "one good journal model."

paper is higher:

$$\begin{aligned}
\Pr\left(\text{Referee Reject } |e>0\right) &= d_1 \\
\Pr\left(\text{NOT Referee Reject } |e=0\right) &= d_2 \\
\Pr\left(\text{Referee Reject } |e=0\right) &= 1-d_2 \\
1-d_2 &> d_1
\end{aligned}$$

Let p be the overall probability of accepting a good paper, and π be the overall probability of accepting a bad paper. Then, it can be shown that:

$$\begin{aligned}
p &= \Pr\left(\text{Accept } |e>0\right) = (1-\alpha)\left(1-d_1\right), \text{ and} \\
\pi &= \Pr\left(\text{Accept } |e=0\right) = \beta \times d_2.
\end{aligned}$$

These are the respective probabilities of a tenure-track faculty, who exerts effort and who does not exert effort, to get a tenured-professor position. It is clear that, given $1-\beta > \alpha$ and $1-d_2 > d_1$, a hard-working academic is more likely to become a tenured professor ($p > \pi$). The term $p-\pi$ is, therefore, a measure of the precision of the editorial process. The larger $p-\pi$ the more accurate is the academic editorial process.

An increased level of precision in the editorial process, a higher $p-\pi$, manifests in a greater ability of editors to identify bad papers (lower α and β) and a greater ability of referees to distinguish bad papers from good papers (lower d_1 and d_2).

2.3 Effort Determination and the Research Effort Condition (REC)

Since a teacher would get the wage w_T indefinitely, and a tenured professor would get the wage w_P indefinitely, their expected lifetime utilities are simply:

$$V_T = \frac{w_T}{r}$$
$$V_P = \frac{w_P}{r}$$

where r is the subjective discount rate, and V is the expected lifetime utility of the respective academic.

The tenure-track researcher's decision to invest effort will be induced by the wage gap between tenured professors and teachers. The expected lifetime utility of a hard-working ($e > 0$) academic whose instantaneous wage is w, as inferred from the fundamental asset equation, is given by:

$$V_e = \frac{(w - e) + pV_P + (1 - p)\, V_T}{1 + r}. \tag{1}$$

With probability p the researcher's good paper is accepted, and she becomes a tenured professor. Otherwise, she proceeds in academia as a teacher. The discounted expected lifetime utility of the tenure-track employee who decides not to invest effort in research (referred to as ne) is similarly defined:

$$V_{ne} = \frac{w + \pi V_P + (1 - \pi) V_T}{1 + r}. \tag{2}$$

The researcher will choose to invest effort in her work if and only if doing so brings her higher lifetime utility. In other words, the following condition must be satisfied:

$$V_e \geq V_{ne}$$

which we call the *Research Effort Condition (REC)*. Substituting the relevant terms into the REC condition yields:

$$w_P \geq w_T + \frac{re}{p - \pi}$$

The REC condition implies that all tenure-track junior researchers choose to exert real effort in research. This is guaranteed by the minimum wage gap between tenured professors and teachers, $re/(p - \pi)$. The REC boundary, which is the lowest wage to secure research effort in equilibrium, is given by:

$$w_P = w_T + \frac{re}{p - \pi} \tag{3}$$

Given the assumption that failing to attain the tenured-professor position is irrevocable (i.e., the tenure-track academic turns into a teacher for eternity), the wage of the tenured professor, or the wage gap between a professor and a teacher $w_P - w_T$, is *not* a function of the number of professors or their share in the academic workforce. In other words, the REC boundary is a horizontal line in the wage-professors space. The labor demand for tenured professors is a decreasing curve in that space.

Expressing the REC boundary in terms of the fundamentals of the publication process, substituting for p and π, gives:

$$w_P = w_T + \frac{re}{(1-\alpha)(1-d_1) - \beta d_2}. \tag{4}$$

2.4 Market Equilibrium and Comparative Statics

Market equilibrium occurs where the aggregate labor demand for professors, given by $w_P^{Demand} = w_T + g'(P)$, intersects with the REC frontier: $w_P^{REC} = w_T + re/[(1-\alpha)(1-d_1) - \beta d_2]$. Define G as the professor-teacher wage gap:

$$G = w_P - w_T$$

then the inverse demand for professors can be expressed in terms of this gap: $G^{Demand} = g'(P)$, and likewise the REC condition can be expressed similarly: $G^{REC} = re/(p-\pi)$, as is clear from Equation (3). These quantities are equalized in equilibrium:

$$g'(P) = \frac{re}{p-\pi} = \frac{re}{(1-\alpha)(1-d_1)-\beta d_2}$$

implicitly determining the number of tenured professors in equilibrium. The remaining academics are employed as teachers, T, with their respective wage, w_T. In equilibrium, there is a nontrivial share of academics who serve in each track: tenured professors and teachers. Neither type of job is a priori dominating the other. The wage gap between a tenured professor and a teacher, G, is also maintained in equilibrium.

The higher the precision of the academic editorial process $(p-\pi)$ the lower is the wage that needs to be paid to professors (w_P) for them to exert research efforts early in their careers; and thus the lower the wage gap between professors and teachers:

$$\frac{\partial G}{\partial (p-\pi)} < 0$$

The effect of a change in the other parameters of the model on the wage of professors and, thus, the wage gap is easily verifiable:

$$\frac{\partial G}{\partial r} > 0, \quad \frac{\partial G}{\partial e} > 0$$

An increase in the discount rate or an increase in the required effort to produce good papers, necessitate a higher wage for professors and results in a higher wage gap between professors and teachers.

A change in one of these parameters shifts the REC curve respectively, while leaving the professors labor demand unchanged. Assuming a downward sloping curve of demand for professors, $g''(P) < 0$, it is clear that in equilibrium:

$$\frac{\partial P}{\partial (p-\pi)} = \frac{\partial P}{\partial G} \times \frac{\partial G}{\partial (p-\pi)} > 0$$

and, likewise, $\partial P/\partial r < 0$ and $\partial P/\partial e < 0$. An upward shift of REC, due to an increase in the discount rate or the effort needed for good research, for example, increases the wage gap and reduces the number of tenured-professor positions. An increase in the precision of the editorial process, on the other hand, lowers the equilibrium wage of professors compared to teachers, and increases their number among the academic personnel, thus improving the overall welfare of society.

3 Simulation, Calibration, and Extensions

3.1 Simulated Comparative Statics

To simulate the effects of a change in the fundamentals of the editorial process $(\alpha, \beta, d_1, d_2)$, we use a subjective discount rate of $r = 10\%$, and an estimate of the research effort, e, which relies on estimates of the "value" of an article in the literature. Tuckman (1976) conjectured that the differentials in rewards for publishing papers between different fields are due to the differentials in the costs of "article production." We thus take the reward for an article as a proxy for e, the effort of producing it.

Sauer (1988) estimated that a standard article in the *American Economic Review* (AER) was worth \$723 in 1982 dollars (\$1798 in 2016 dollars, or a wage increase of approximately 2%). Incorporating the added value of citations, the reward was estimated to be \$1602 (\$3985 in 2016 dollars), representing a 3.8% increase in compensation at the time. The lifetime discounted value of this increase is equivalent to \$39,850. We thus use this value as a proxy for e in our simulation.[9]

The professors-teachers wage gap that satisfies the REC (from Equation 4) is given by:

$$G = \frac{re}{(1-\alpha)(1-d_1) - \beta d_2} = \frac{3985}{(1-\alpha)(1-d_1) - \beta d_2}$$

Assuming the probability of reviewers accepting a bad paper is 0.1, $d_2 = 0.1$, we simulate the effect of changes in the editorial process fundamentals on the professors-teachers wage gap—alternatively, on the number of tenured-professors in the academic community. We show the effect of introducing the "desk-rejection" policy on the professor-teacher wage gap, as well as a few scenarios of different desk-rejection policies, as a function of the probability

[9] Attema, Brouwer, and Van Exel (2014), notwithstanding, estimated the "willingness to pay" for an AER paper to be \$12658 (an 8% wage increase).

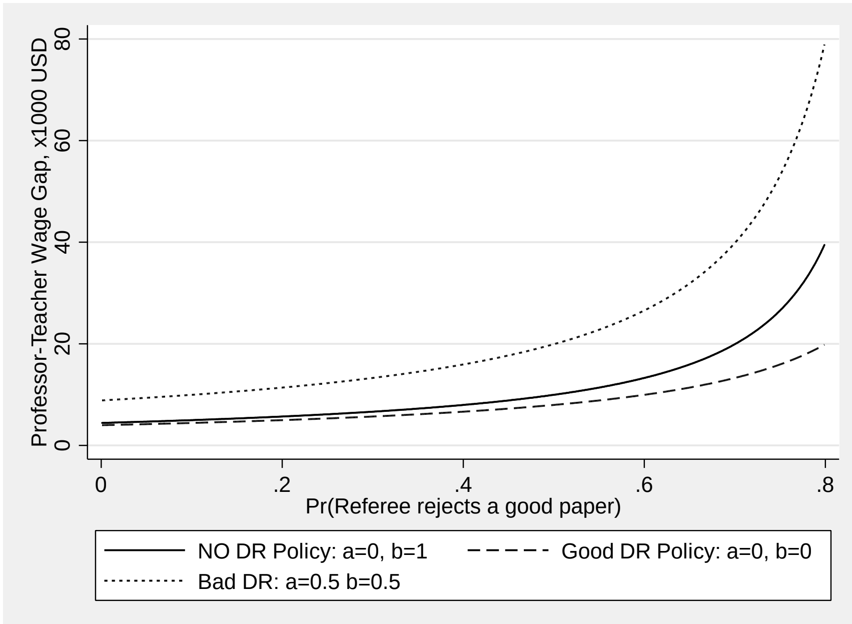

Figure 1: Professor-Teacher Wage Gap

of referees rejecting good papers. Figure 1 shows the results of this simulation.

The professor-teacher wage gap increases with the imprecision of the editorial process—when referees are more prone to the error of rejecting good papers. The introduction of the desk-rejection policy can slightly offset these negative effects, but only if it is a "good" policy: in that editors are not susceptible to any of these errors (their probability of desk-rejecting a good paper is zero, $\alpha = 0$; and their probability of forwarding a bad paper to reviewers is zero, $\beta = 0$). Otherwise, introducing a desk-rejection policy can exacerbate the problem, if editors experience a large margin of error: the figure shows the case for $\alpha = \beta = 0.5$ as the "bad desk-rejection policy."

Assuming $g(P) = a + b\ln(P)$ in the university production function, the inverse demand

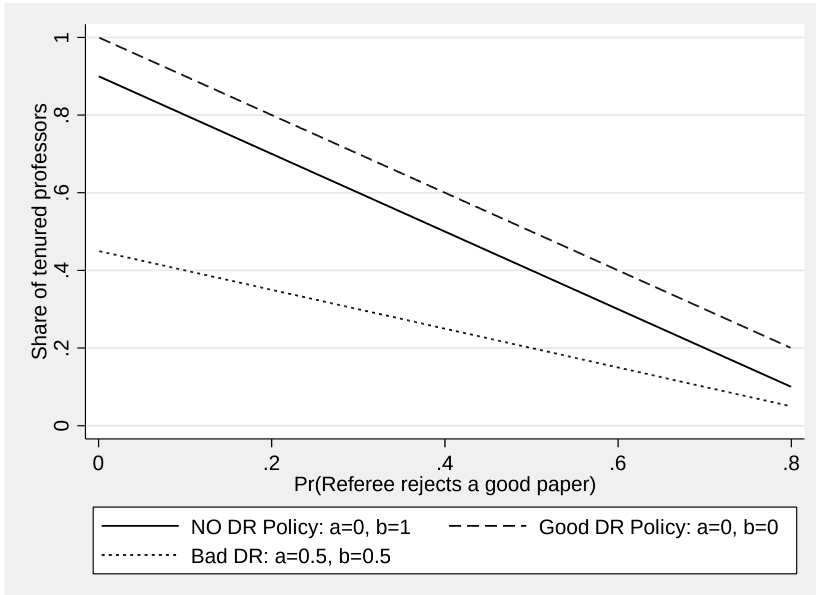

Figure 2: The Share of Tenured Professors

for professors would be given by $w_P^{Demand} = w_T + b/P$ or, in terms of professor-teacher gaps, $G = b/P$. The maximum share of professors, at the ideal editorial process standard ($\alpha = \beta = d_1 = d_2 = 0$), is normalized to 1 by assuming $b = re$. So that P here represents the share of the tenured professors in the academic workforce. Using these assumptions, Figure 2 shows the share of tenured professors in the academic workforce as a function of the probability of referees rejecting good papers, under different desk-rejection policies.

The share of tenured-professors is negatively related to the imprecision in the editorial process. A "bad" desk-rejection policy adds to the imprecision of the editorial process, exacerbating the problem as it manifests in lowering the share of tenured professors in academia. Conley (2012) voiced similar opinion about the detrimental effect of these imprecisions: "If institutions do not internalize the effect of the new publishing environment, then fewer junior faculty will receive tenure than in the past."

Eventually, the high probability of rejecting good papers does not justify the effort invested in producing these papers, diminishing the share of tenured professors, and negatively affecting the overall quality of teaching and research in academia.

3.2 Basic Calibration

There has been a noticeable decrease in tenured-professor positions in academia, along with an increasing wage gap between tenured professors and untenured or tenured teachers (AAUP 2017). An event that is likely consistent with these stylized facts is an upward shift in the REC curve. Given the comparative statics shown above, one concludes that a combination of the following may have happened: an increase in the discount rate r, an increase in the effort needed for producing good research e, an increase in the probability of rejecting good papers, and a decrease in the ability to detect bad papers.

The change in the interest rate is less likely, given the actual decrease in the national interest rates in the last four decades. The increase in the effort needed to produce good research is, however, a likely candidate and is indeed well-documented in the literature (Ellison 2002; Card and DellaVigna 2013; Berk, Harvey, and Hirshleifer 2017).

The trends are also consistent with the hypothesis that the precision of the editorial process in academic journals has been declining. In particular, good papers might have been rejected at an increasing rate, that has been driven by artificial space constraints imposed

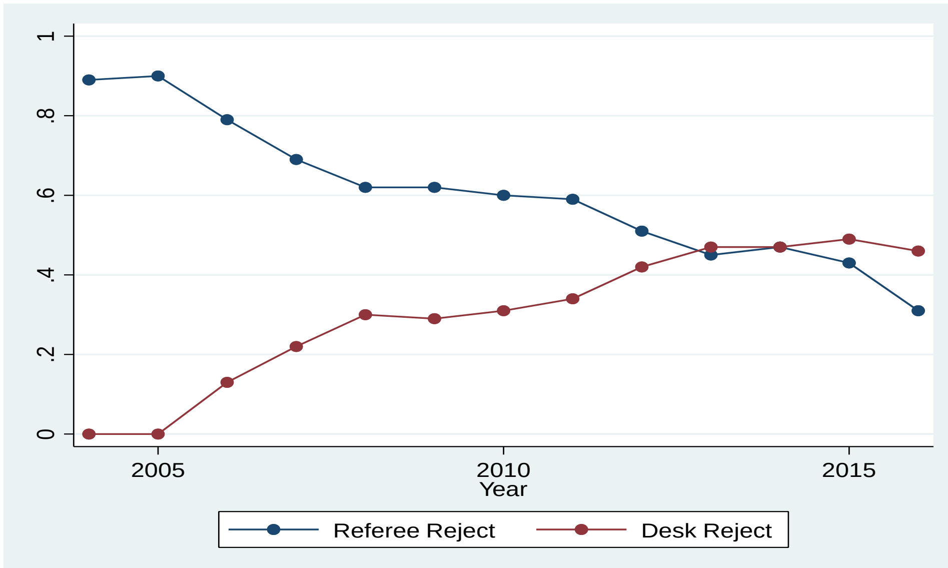

Figure 3: Referee and Desk Rejection Rates at the American Economic Review

by commercial publishers or by the desire of editors to increase the apparent quality of their journals: "Surely a journal with an acceptance rate of 5% is higher quality and more prestigious than one with a rate of 20%." (p.7, Conley 2012). As implied by our model, this can go a long way in explaining the eroding share of tenured-professor positions in academia.

Taking an example from the economic literature, Figure 3 reports the rates of desk rejection and referee rejection at the American Economic Review (AER) over the last decade.[10]

Up to 2005 there was no desk-rejection policy at the AER. The probability of desk-rejection has started increasing since the policy was first introduced in 2006, reaching a level of about 50% within a decade.[11] The graph shows the unconditional rejection probabilities,

[10] These data were gleaned from the respective yearly reports of the editors of the AER.

[11] At the Journal of Political Economy, for example, a similar desk-rejection rate of 55% was reported for the years 2017-18. (Editors. 2019. "JPE Turnaround Times." *Journal of Political Economy* 127(1): 463.)

which can be represented by the following:

$$\Pr(\text{Desk-Rejct}) = \alpha \times \Pr(e > 0) + (1-\beta) \times \Pr(e = 0)$$

$$\Pr(\text{Referee-Reject}) = (1-\alpha)\, d_1 \times \Pr(e > 0) + \beta\,(1-d_2) \times \Pr(e = 0)$$

In equilibrium, where REC is satisfied, we know that $\Pr(e > 0) = 1$, all juniors invest effort. However, at any observable moment the system can still be in a disequilibrium, in that it is possible that at any point in time $\Pr(e > 0) < 1$.

If we assume, say in 2005, when there was no desk-rejection policy yet ($\alpha = 0$, $\beta = 1$), the system was in equilibrium, then we can infer that $\Pr(\text{Referee-Reject } | e > 0) = d_1 = 0.9$. In 2006, with $\Pr(\text{Desk-Rejct}) = 0.13$ and $\Pr(\text{Referee-Reject}) = 0.79$, the probability of desk-rejecting good papers would be $\alpha = 0.13$, and the probability of referees rejecting good papers would be $d_1 = 0.91$. Introducing the desk-rejection policy naturally increased the probability of type-I error (rejecting good papers) by editors , but also increased the probability of type-I error by the referees as well. This is a decline in the precision of the editorial process, even assuming that editors and referees never accept bad papers.

Alternatively, if we assume that the system was in disequilibrium in 2005, so that there were some researchers not investing effort, $\Pr(e > 0) < 1$, then we have to impose additional assumptions on the parameters to identify the values of the other parameters, and to identify the share of researchers who invest effort. Assuming that referees never accept a bad paper, that is $d_2 = 0$, and that they reject good papers with a probability of 0.8 $(d_1 = 0.8)$, then the share of good submitted papers (or of researchers who invested effort) would have been 50%.

Maintaining these assumptions for 2006, we find that $\alpha_{2006} = 0.20$. This value is not consistent with the assumption that editors are less likely to reject a good paper than a bad one, that is $\alpha < 1 - \beta$. For that assumption to hold it must have been the case that d_1 increased (from the original 0.80). Assuming $d_1^{2006} = 0.82$, we can identify the likely values of α and β for 2006, namely $\alpha_{2006} = 0.11$ and $\beta_{2006} = 0.85$. Once again, the introduction of the desk-rejection policy in 2006 resulted in higher probabilities of rejecting good papers, both by editors and referees. This outcome is consistent with an increasing imprecision in the editorial process which, given the simulation in the previous section, contributes to an increasing professor-teacher wage gap and a decreasing share of tenured-professor positions in the profession.

3.3 Possible Extensions

3.3.1 Academic Labor Force Dynamics

So far we have assumed that the academic labor force is not growing. A given body of junior researchers decide whether to invest effort in the first period and then, by the outcome of their research efforts, they are directed to tenured-professor positions or to teacher positions, without the possibility of repeating the process or changing positions. In this case the REC curve is flat,[12] and it guarantees that all junior researchers invest a given research effort in the first period.

The model remains intact if we allow for workforce dynamics and assume that there is a constant inflow of newly-minted PhD junior researchers into academia, and an equal outflow of academics (professors and teachers) from academia, say due to retirement. Likewise the model results remain unaltered should there be a constant growth in the academic population—a proportional inflow of academics into academia with less than proportional outflow from academia.

This latter outcome—of unaltered REC even with the presence of a growing academic community—is guaranteed only if p and π, the probabilities of accepting a good and a bad paper for publication, or at least their difference $p - \pi$, are not functions of the size of the academic community. This is a reasonable assumption in the longer run, given that the number of journals has been increasing at roughly the same rate as the number of researchers (Mabe 2003).

If in the shorter run, however, the number of researchers outgrows the number of journals, the probability of accepting good papers might decrease—likely even more than the decrease in the probability of accepting bad papers, simply due to space considerations. In this case the REC curve would be increasing with P (the number, or the share, of tenured professors). With an upward sloping REC, the direction of the comparative statics, with respect to any

[12] In that the wage of professors is higher than the wage of teachers, but is fixed regardless of the number or the share of tenured professors in equilibrium.

of the model parameters like the publication process fundamentals, the effort, or the discount rate, would *not* be altered. The magnitude of these effects, however, would be reduced, for any given downward-sloping demand curve.

3.3.2 Heterogenous Ability

The basic model has assumed that all new junior recruits are of equal ability. The model can be extended to include researchers of different abilities. In particular, assume there are two types of junior researchers: high-ability researchers and low-ability researchers. The share of high-ability researchers is $h \in (0,1)$. The effort invested in research, e, is the same for both types; however, that same effort is more effective for the high-ability researchers, in that the probability of accepting their good papers, p_1, is greater than the probability of accepting the good papers of the low-ability researchers, p_0—implicitly introducing a variation in the quality of effort-produced papers (good papers, and better ones). At the same time, we assume that ability does not substitute for effort. In other words, papers produced without effort are equally likely to be accepted, whether they have been produced by high-ability researchers or by low-ability researchers. That is, $\pi_1 = \pi_0 = \pi$, where π_1 is the probability of accepting a bad paper from the abler researcher, and π_0 is the probability of accepting a bad paper from the low-ability researcher.[13] The researcher knows her type, but the university does not a priori observe that type.

[13] Still maintaining the assumption that effort increases the probability of acceptance, that is $p > \pi$; in this case $p_1 > p_0 > \pi$.

In this setting, the REC condition implies that, for the high-ability workers, $w_P^h \geq w_T + re/(p_1 - \pi)$; and for the low-ability workers $w_P^l \geq w_T + re/(p_0 - \pi)$. It is clear that the tenured-professor wage required by the low-ability researchers, for them to exert research effort, is higher than that required by the high-ability researchers: $w_P^l > w_P^h$.

There are two cases to consider: first, when the university wants to elicit effort from all the junior researchers; and, second, when the university wants to elicit effort only from the high-ability researchers.

Eliciting Effort from *All* Junior Researchers To elicit effort from all junior researchers, the university sets the wage of tenured professors at the higher wage $w_P^l : w_P = w_P^l$. That, in turn, determines the REC and the equilibrium levels of the wage and the share of tenured professors.

Starting from a mixed-ability labor force, or low-ability-only labor force—i.e., assuming $h \in [0, 1)$—the REC boundary would be set at w_P^l, and would *not* change whether low-ability or high-ability academics join the junior labor market. Therefore, the number of tenured professors in equilibrium and their wage (or wage premium) would not change as well. Yet in both cases the share of high-ability academics in the pool of successful researchers and, by extension, in the pool of tenured professors, would be higher than the share of high-ability academics in the pool of teachers.

In particular, in equilibrium the $\Pr(\text{high-ability}|\text{accepted papers}) = p_1 h/[p_1 h + p_0(1-h)]$, and the $\Pr(\text{high-ability}|\text{rejected papers}) = (1-p_1)h/[(1-p_1)h + (1-p_0)(1-h)]$. It is straightforward to show that, for any $h \in (0,1)$:

$$\Pr(\text{high-ability}|\text{accepted papers}) > h > \Pr(\text{high-ability}|\text{rejected papers}).$$

In this case, the wage premium of professors is partly expressive of the ability premium. The REC would shift upwards, lowering the number of tenured professors and increasing their wage, only if a high-ability-only labor force ($h = 1$) is joined by some low-ability researchers.

Eliciting Effort Only from *High-Ability* Junior Researchers Alternatively, if the university is interested in eliciting research effort only from the high-ability researchers, then, as would be implied by the "intuitive criterion" of Cho and Kreps (1987), w_P would be set at the lowest possible wage needed to elicit this effort, which is w_P^h. In this case, on the REC boundary only high-ability researchers exert effort, while low-ability researchers do not exert any research effort.

Starting from a mixed-ability labor force, or high-ability-only labor force—i.e., assuming $h \in (0,1]$—the REC would not shift whether the junior labor force is joined by either high-ability or low-ability researchers. While the number of tenured professors and their wage would be maintained, the composition of this group changes in that the share of high-ability academics among professors becomes higher than their share among teachers. This follows from the same argument as in the first case:

$$\begin{aligned}\Pr(\text{high-ability}|\text{accepted papers}) &= \frac{p_1 h}{p_1 h + \pi(1-h)}, \text{ and} \\ \Pr(\text{high-ability}|\text{rejected papers}) &= \frac{(1-p_1)h}{(1-p_1)h + (1-\pi)(1-h)},\end{aligned}$$

and therefore

$$\Pr(\text{high-ability}|\text{accepted papers}) > h > \Pr(\text{high-ability}|\text{rejected papers}).$$

Finally, notice that the share of tenured professors would be lower, and their wage higher, in a low-ability-only labor force, as compared to the case of a high-ability-only labor force. This means that, in the continuous ability case, when lower-ability researchers join the labor market they drive the professor-teacher wage gap upwards; lower the share of tenured professors in equilibrium; and increase the ability gap between the two groups (the share of high-ability academics among professors becomes higher, and their share among teachers becomes lower).

4 Caveats

4.1 Research Effort and Coauthors

The rise in the difficulty of publishing articles in academic journals, and thus the rise in the associated effort e, have been brought up in this study as a possible explanation for the eroding tenured professorship in academia. At the same time, however, the number of authors per paper have been steadily increasing in the last decades. From a rarity in the 1950s, multiple authorship became commonplace by the 1990s (Hudson 1996; Ellison 2002; Card and Della Vigna 2013). This trend has been observed in almost all fields of academic inquiry (Woods et al. 2010).

Inasmuch as the effort per paper is reduced due to collaboration, the *adjusted* effort per author/paper might have been declining instead. This, in turn, leaves the increasing imprecision in the academic editorial process as the only viable explanation for the increasing professor-teacher wage gap and the eroding role of tenured professorship in academia.

Yet it is not straightforward to link the increase in the number of coauthors to a potential decline in the (adjusted) effort, since this literature (see Ellison 2002; and Card and Della Vigna 2013, for example) shows that the increase in the number of authors per article might be linked to an increasing complexity of producing research papers—indeed an effective *increase* in the associated effort per author/paper. Besides, Card and Della Vigna (2013) found that the average paper length has been growing faster than the number of authors per paper, which also indicates a possible increasing effort per author/paper despite the increased number of authors per paper.

Furthermore, it is not clear whether the value of a publication for the individual author is unrelated to the number of authors per paper. McDowell and Melvin (1983), studying academic papers in economics, concluded that single authors should receive more credit. Consequently, coauthored papers might not be as valuable to the individual author as single-authored papers. Therefore, even if more coauthors per paper potentially reduce the effort exerted by each author, that advantage might be offset by the potential decline in the value each author gets from the coauthored paper. In other words, the net effort might still have increased despite the increase in the number of coauthors.

4.2 Tenure and Academic Publishing: Complementary Interpretation

So far we emphasized the effect of the imprecision of the academic editorial process on the tenure system in academia, namely on the share and the wage of tenured-professors as opposed to contingent teaching faculty. This causality, however, can be reversed; or it can be bidirectional.

It is possible that, say due to the fact that tenured-professor positions are strictly preferred over teaching positions,[14] junior researchers submit much more working papers for

[14] An assumption that has been made earlier in the model section, expressed as: $g'(P) > e$.

publication in leading journals; the sheer number of submissions admits of the fact that many of these papers might be bad papers, which will lead to an increase in the rejection rates—naturally accompanied by an increasing margin of error on the editors' and the reviewers' end. This result is also consistent with the observed relationship between the trends in academic employment and academic publishing. Allowing for feedback effects, moreover, contributes to the persistence of these trends.

5 Conclusions

While tenured and tenure-track jobs had been the norm for a long time in academia, their share has been declining in the last four decades. Full-time and part-time non-tenure-track teaching jobs are increasingly replacing traditional tenure-track and tenured jobs. By extrapolation, one can expect this trend to proceed unhampered up to the abolition of tenure in academia.

Ample motivations have been offered in the literature to support either contingent teaching or tenure-track research contracts in academia, expecting a dominance of one contract over the other, under different circumstances. The coexistence of these two tracks received relatively less attention. The current study explains the coexistence of teachers and tenured professors in institutions of higher education, and also it points to the possibility that this coexistence is an equilibrium phenomenon, in that it postulates a nontrivial steady-state share of teachers and tenured-professor positions in academia.

The difficulty of producing academic research and the challenge of the academic publication/editorial process explain the changes in the composition of the academic labor force. The recent declining trend in the share of tenured-professor jobs and the increasing wage gap between teachers and tenured professors are consistent with the documented fact that academic research is becoming more difficult and are consistent with the likely increasing imprecision in the academic editorial process, as implied by the model. If, instead, we maintain the assumption that the difficulty of conducting research has not been increasing, then the increasing imprecision in the editorial process would play a more important role in explaining the observed diminishing share of tenured professors in academia.

The imprecision in the editorial process might be manifested in editors summarily rejecting good papers, that would have survived the review process had they been forwarded to referees for additional evaluation, and in the high level of arbitrariness in the review process and in the work of referees (as postulated by Berk, Harvey, and Hirshleifer 2017).

Gains in the profession might accrue from more precise, and more prompt, desk-rejection of bad papers by the editors. However, a worrying sign is that these gains might be overshadowed by an increase in the probability of rejecting good papers, both by editors and referees. Taking the cautious approach of erring on the "safe-side," by preferring the rejection of good papers to the acceptance of bad papers (or by simply increasing the rejection rate in general) is *not* a step in the right direction: it will likely diminish the number of hard-working academics and reduce the share of tenured professors in academia, eventually decreasing the quality of research and teaching in institutions of higher education.

Finally, it is worth emphasizing that the effort needed to secure good publication is not easily determined or measured, given the fact that in almost all fields of scientific inquiry the number of authors per paper has been increasing. Secondly, while the imprecision of the editorial process might have bearing on the issue of tenure in academia, a reverse-causality interpretation should be entertained, in that the increasing competition for tenured-professor positions in academia might itself have spurred an increasing volume of working-paper submissions, that resulted in an increasing rejection rates at academic journals—and, inevitably, an increasing margins of error in the editorial process.

References

Aarssen, L.W. 2012. "Are peer-review filters optimal for the progress of science in ecology and evolution?" *Ideas in Ecology and Evolution* 5:9–12.

American Association of University Professors. 2017. "Visualizing Change: The Annual Report on the Economic Status of the Profession, 2016-17." *Academe* 103(2): 4-26.

American Association of University Professors. 1992. "On the status of non-tenure-track faculty." *Academe* 78(6): 39-48.

American Psychological Association. 2017. "Summary report of journal operations, 2016." *American Psychologist* 72(5): 499-500.

Asali, Muhammad. 2018. “A Tale of Two Academic Tracks.” *IZA Discussion Papers* 11423.

Attema, Arthur E.; Brouwer, Werner B. F.; and Van Exel, Job. 2014. “Your right arm for a publication in AER?” *Economic Inquiry* 52(1): 495-502.

Baghestanian, Sascha and Popov, Sergey V. 2018. “On Publication, Refereeing, and Working Hard.” *Canadian Journal of Economics* 51(4): 1419-1459.

Baron, James N., and Kreps, David M. 1999. *Strategic human services: Frameworks for general managers.* New York: Wiley.

Berk, Jonathan B.; Harvey, Campbell R.; and Hirshleifer, David. 2017. “How to Write an Effective Referee Report and Improve the Scientific Review Process.” *Journal of Economic Perspectives* 31(1): 231-44.

Bhagwati, Jagdish, and O’Flaherty, Brendan. 2001. “Professors who defend tenure: Are they hypocrites?” *Chronicle of Higher Education* B24.

Brogaard, Jonathan; Engelberg, Joseph; and Van Wesp, Edward. 2018. “Do Economists Swing for the Fences after Tenure?” *Journal of Economic Perspectives* 32(1): 179-194.

Card, David, and DellaVigna, Stefano. 2013. “Nine Facts about Top Journals in Economics.” *Journal of Economic Literature* 51(1): 144-61.

Carmichael, H. Lorne. 1988. “Incentives in Academics: Why Is There Tenure?” *Journal of Political Economy* 96(3): 453-472.

Cater, Bruce; Lew, Byron; Pivato, Marcus. 2017. "The efficiency of tenure contracts in academic employment." *Journal of Public Economic Theory* 19(2): 331–361.

Cater, Bruce; Lew, Byron; Smith, Barry. 2008. "A Theory of Tenure-Track Contracts." *Education Economics* 16(2): 203-218.

Chen, Zhao; Lee, Sang-Ho. 2009. "Incentives in Academic Tenure under Asymmetric Information." *Economic Modelling* 26(2): 300-308.

Cho, In-Koo, and Kreps, David M. 1987. "Signaling Games and Stable Equilibria." *Quarterly Journal of Economics* 102(2): 179–221.

Conley, John P. 2012. "Low acceptance rates, commercial publishing, and the future of scholarly communication." *Economics Bulletin* 32(4): A37.

DiPiro, Joseph T. 2013. "Acceptance and rejection of manuscripts for publication in the American journal of pharmaceutical Education." *American Journal of Pharmaceutical Education* 77(4): 66.

Ehrenberg, Ronald G. 2004. "Prospects in the Academic Labor Market for Economists." *Journal of Economic Perspectives* 18(2): 227-238.

Ehrenberg, Ronald G.; Zhang, Liang. 2005. "Do Tenured and Tenure-Track Faculty Matter?" *Journal of Human Resources* 40(3): 647-659.

Ellison, Glenn. 2002. "The slowdown of the economics publishing process." *Journal of Political Economy* 110(5): 947–993.

Figlio, David N.; Schapiro, Morton O.; and Soter, Kevin B. 2015. “Are tenure track professors better teachers?” *Review of Economics and Statistics*, 97(4): 715-724

Hattie J. & Marsh H. W. (1996). “The relationship between research and teaching: A meta-analysis.” *Review of Educational Research* 66 (4): 507-542.

Hattie J. & Marsh H. W. (2004). One journey to unravel the relationship between research and teaching. Paper presented at Research and Teaching: Closing the Divide? An International Colloquium, Winchester, March 18-19.

Hudson, John. 1996. “Trends in Multi-authored Papers in Economics.” *Journal of Economic Perspectives* 10(3): 153-158.

Kasper, Hirschel. 1986. “On Understanding the Rise in Non-Tenure Track Appointments.” Working Papers (Industrial Relations Section, Princeton University).

Kimmitt, Michael C. 2009. “A Model of Adjuncts in Higher Education.” *Economics Letters* 105(1): 68-70.

Mabe, Michael. 2003. “The growth and number of journals.” *Serials* 16(2): 191-197.

McDowell, John M.; Melvin, Michael. 1983. “The determinants of coauthorship: An analysis of the economics literature.” *Review of Economics and Statistics* 65(1): 155-160.

Nature Editorial. 2012. “A decade in numbers.” *Nature Materials* 11: 743-744.

Popov, Sergey V. 2015. “Tenure-Track Contract Helps Self-Selection.” *Economics Bulletin* 35(4): 2482-2486.

Sauer, Raymond D. 1988. “Estimates of the returns to quality and coauthorship in economic academia.” *Journal of Political Economy* 96(4): 855-866.

Scott, Charles E., and Siegfried, John J. 2017. “American Economic Association Universal Academic Questionnaire Summary Statistics.” *American Economic Review: Papers & Proceedings* 107(5): 678-680.

Scott, Charles E., and Siegfried, John J. 2011. “American Economic Association Universal Academic Questionnaire Summary Statistics.” *American Economic Review: Papers & Proceedings* 101(3): 664-667.

Shapiro, Carl; Stiglitz, Joseph E. 1984. “Equilibrium Unemployment as a Worker Discipline Device.” *American Economic Review* 74(3): 433-444.

Solow, Robert M. 2014. “Foreword.” In: Szenberg, Michael and Ramrattan, Lall, ed. *Secrets of Economics Editors*, xii. Cambridge, MA: MIT Press.

Tuckman, Howard P. 1976. *Publication, Teaching, and the Academic Reward Structure.* Lexington, Mass.: Heath.

Wardle, David A. 2012. “On plummeting manuscript acceptance rates by the main ecological journals and the progress of ecology.” *Ideas in Ecology and Evolution* 5: 13-15.

Woods, Robert H.; Youn, Hyewon; Johanson, Misty M. 2010. “Single vs. Co-Authored and Multi-Authored Research Articles: Evaluating the views and opinions of ICHRIE Scholars." *International CHRIE Conference-Refereed Track* 11. <https://scholarworks.umass.edu/refereed/CHRIE_2010/Saturday/11>

Zhang, Liang; Ehrenberg, Ronald G.; Liu, Xiangmin. 2015. "Changing Faculty Employment at Four-Year Colleges and Universities in the United States." *NBER* No. 21827.