UNIVERSITY OF SURREY

Discussion Papers in Economics

DOES TENURE MAKE RESEARCHERS LESS PRODUCTIVE? THE CASE OF THE "SPECIALIST"

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DP 05/14

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ISSN: 1749-5075

Does Tenure Make Researchers Less Productive?

The Case of the "Specialist"

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August 10, 2014

Abstract

Many studies suggest that research productivity falls after tenure is granted. We have however limited choice-theoretic understanding of why this should occur. With some simplifying assumptions, we rationalize this as follows. Scholars are assumed to be "specialists": their research productivity consists in transforming Ph.D. chapters into publishable papers. We show how a department that hired such a scholar provides incentives to maximize research productivity. We show his research productivity and publication paths are then characterized by a "bang-bang" solution, i.e., either he works with maximum or minimum effort. The department sets the scholar's wages proportional to the department's impatience to spur his productivity, and only succeeds if he turns out to be more impatient than the department. The paper provides a novel perspective on academic productivity and the tenure system.

JEL Classification: D29, A29, M51

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1 Introduction

The Oxford English dictionary defines tenure as "*... guaranteed permanent employment ... after a probationary period*". Although common to many professions (e.g., the judiciary, medicine etc), it tends to be most readily associated with education, being a key (if controversial) part of US academic life.[1]

The literature on the tenure system is considerable, with arguments for and against. This is hardly surprising: the granting of tenure involves many uncertainties. For instance, the tenuring department cannot be sure if research productivity witnessed during the tenure-track period will be sustained. Nor can it be sure that the wage structure for tenure-track faculty sets the correct incentives for such continued productivity.

To add to this uncertainty, the peer-review process in economics in recent years has been characterized by increasing long lags (Ellison (2002), Conley et al. (2013)), lower acceptance rates at the top journals (Card and DellaVigna (2013)), and a trend towards longer manuscripts, Conley et al. (2013). These factors naturally work against those trying to rapidly acquire a publications profile. They also complicate the department's decision making.

Are such uncertainties reflected in the data on tenure decisions? It is not completely clear but certainly there have been some dramatic trends (see **Table 1**). The percentage of relevant institutions with a tenure system in the US fell from 63% (early 1990s) to 45% (2011-12), and effectively to zero in the particular case of for-profit institutions (albeit starting from an already low level). In addition, the percentage of full-time instructional faculty with tenure fell 56% to 49% across all institution types. The percentage of full and associate professors (and staff with no academic rank, "Misc.") with tenure was fairly stable, but this is less so with other categories.

[1] The formalization of tenure in the US is usually associated with the formation of the American Association of University Professors (AAUP) in 1915 and their declaration of the rights and responsibilities of academic staff. Moreover, the number of tenured academic staff accelerated markedly after WWII following demobilization.

Table 1: **Percentage of full-time instructional faculty with tenure for degree-granting postsecondary institutions with a tenure system: Selected years, 1993-94 through 2011-12**

	Institutions with tenure	Total Faculty	Full Professor	Associate Professor	Assistant Professor	Instructor	Lecturer	Misc.
				1993-94				
All institutions	62.6	56.2	91.9	76.8	14.4	38.3	10.8	26.0
Non-profit institutions	62.0	49.5	90.3	67.6	9.0	6.1	21.9	18.9
For-profit institutions	7.8	33.8	95.2	–		32.9		
				1999-2000				
All institutions	55.0	53.7	92.8	76.8	11.8	34.1	3.4	18.3
Non-profit institutions	59.0	48.2	90.3	68.0	7.5	1.8	1.2	7.4
For-profit institutions	4.0	77.4	47.4			86.1		71.9
				2009-10				
All institutions	47.8	48.7	90.3	74.6	7.2	28.2	1.4	24.7
Non-profit institutions	57.1	44.3	87.8	67.2	3.8	0.6	0.3	7.1
For-profit institutions	1.5	51.0	75.5	8.5		87.3		
				2011-12				
All institutions	45.3	48.5	89.7	74.9	6.9	27.3	1.3	23.8
Non-profit institutions	55.6	43.7	87.0	67.8	3.3	0.4	0.3	6.7
For-profit institutions	1.3	31.0	72.3	30.8	1.6	54.4		5.0

Source: U.S. Department of Education, National Center for Education Statistics. Available at: `http://nces.ed.gov/programs/digest/d12/tables/dt12_305.asp`

What lies behind these trends? Probably a variety of factors: budgetary reasons; general trends in the economy towards more flexible working arrangements; greater specialization across institutions in terms of staff profiles; the growth of for-profit institutions; and so on. Given our previous discussion (longer peer-review process, lower acceptance rates, longer manuscripts) these trends may also reflect to some degree dissatisfaction with, and risk aversion towards, the tenure system. To begin to investigate why, let us first review the general arguments in the literature for and against tenure.

The arguments ***in favor*** of the tenure system focus traditionally on *academic freedom*; *cost effectiveness*; *pedagogical quality* (see McKenzie (1996), McPherson and Schapiro (1999), McGee and Block (2001) and Block, 2001); as well as *moral hazard*; and on *academic habits*.

Tenure, it is argued, is necessary to guarantee academic freedom: professors avoid losing their positions for investigating controversial subjects. Therefore, tenure encourages the kind of free-flowing debate that is important in an open society, Machlup (1969).

The cost-effectiveness argument assumes that scholars, unlike say entrepreneurs, are highly risk-averse and the perspective of a job for life makes them willing to work for less than people who have no lifetime employment. Thus, if tenure reduces professors' salaries, it makes education cheaper which benefits students.

The pedagogical quality argument says that only those professors who achieve excellence in teaching, research and service are awarded tenure. This guarantee of excellence reassures students, whose tuition fees have outpaced median real income growth in recent decades, Desrochers et al. (2010).[2]

Carmichael (1988) also argues that tenure solves the moral hazard problem of selecting new faculty members. If universities lack full information to identify the best candidates to hire, while incumbent professors do, the incumbents need tenure to make them reveal the best candidates without fear of jeopardizing their

[2]Borjas and Doran (2015) provide an interesting analysis of the productivity of mathematicians after winning the Fields medal relative to their peers. They show that such prizes can have large effects afterwards on their recipients' effort allocation.

own positions. (See also Takatoshi and Kahn (1986).)

Finally, Faria and Monteiro (2008) suggest that depending on the incentives to attain tenure, the tenure-tack scholar may develop research habits that make him more productive and these habits persist after becoming tenured. As a result tenure can be designed so as to make scholars more productive for their whole academic life.[3]

Critics however have attacked the very arguments given in favor of tenure. For instance, the freedom of expression argument loses its strength alongside examples of "politically correct" censorship in US campuses.[4] Likewise, the pressures to attain tenure may bias scholars towards existing academic paradigms, and away from riskier, more innovative research streams, Smolin (2008).

The pedagogical quality argument – namely that the tenure system is good because it rewards the best candidates – can in turn be criticized for ignoring that tenure can be influenced by favoritism and politicking (Roche (1969)).[5]

Regarding cost-effectiveness, Alchian (2006) stresses that tenure depends upon the absence of competition among universities. The lack of competition allows universities to hire unproductive scholars and sustain unproductive tenured professors because their full cost is not paid by them. Therefore tenure may in fact be far from cost effective. Alchian also argues the non-profit status of academic institutions allows more managerial "shirking". One of the ways in which mangers shirk in the non-profit case is described thus (p. 383) "...as it is not in a profit-seeking owned institution ... the administrator will more frequently evidence arbitrariness in hiring and firing people." Tenure thus protects faculty against such arbitrary decisions.

Critics say that tenure creates incentives for academics to become less pro-

[3]This accords with the Merton et al. (1957) thesis. They explain scholarly productivity as a response to an internalized value of the professional role inculcated into the scholar through the immersion in a professional peer culture. The granting of tenure does not change this value neither does it alter scholarly productivity.

[4]See, for instance, Timmons (1990), (Goode, 1991a,b), Scott (1991).

[5]Dershowitz (1990) gives an example that contradicts at the same time the freedom of expression and the pedagogical quality arguments: a female assistant professor denied tenure at Harvard Law School because the female faculty argued that she was not feminist enough.

ductive, since once tenured they lose motivation for research, Bess (1998). Holley (1997) for instance shows evidence that there are substantial differences in research productivity prior and after tenure, with pre-tenure output being the greater.[6] According to Becker et al. (1961) the granting of tenure removes an important external threat of sanction, which reduces the institution's power and control.[7]

Our contribution focuses on this last, perhaps most trenchant criticism: that tenure makes previously productive scholars unproductive. As far as we are aware, this outcome has not been formalized theoretically. And yet it is at the heart of the debate over tenure. What factors would lead to such an outcome? What remedial strategies could the tenuring institution implement? This is the subject of our paper.

At the outset let us be clear about who we have in mind, and who we do not. The bulk of tenured academics are dedicated members of the scientific community. The scholar we consider, however, is characterized by specialization in a narrow field. In addition, he is not interested in widening his intellectual horizons; holding a Ph.D. degree is the pinnacle of his intellectual life. This individual when hired by an academic department limits himself to "milking" the chapters of his Ph.D. by transforming them into publishable papers in journals of his field.[8] Clearly, though, this strategy has a limit since there must be a finite number of papers to be published out of a dissertation.

Naturally, the same scholar may desire tenure, so he has an incentive to be as productive as possible in order to be promoted, given the department's incentives

[6] Levin and Stephan (1991) show a reduction in research productivity due to life cycle effects, since the aging academic becomes less productive. Oster and Hamermesh (1998) show that economists' productivity (as measured by publication in top journals) declines sharply with age.

[7] A related argument is that tenure impedes resource (re-)allocation given hiring and firing constraints, see Chait (2002).

[8] The milking process is not a one-to-one relation between Ph.D. chapters and publishable papers. For instance, there may be many scholars who can multiply a single thesis chapter into multiple articles. This occurs because being repetitive is not necessarily always punished in academia. Some applied economists redo and publish (what amounts to) the same study by, for instance, implementing straightforward changes to their original data set, or minor variations on their methodology.

[wages and other rewards], tenure window [academic advancement timeline] and criteria to grant tenure and promotion [e.g., number of publications]. In this, there are two important issues to consider.

First, as soon as the scholar exhausts this finite resource, he becomes unproductive. He only hopes he can achieve tenure before running out of resources. If he becomes tenured and continues to be productive, after a few years he will turn out to be completely unproductive.

The second issue is that for every year of his tenure clock, he obviously has – by dint of finite resource and time constraints – a minimum and maximum number of papers that can be published.[9] This fact combined with the department's incentives such as to link salary advances to research productivity, may yield discontinuities in the path of the specialist's research effort, and possibly a "bang-bang" solution.[10]

An interesting and important consequence arises from the above scholar theory. If he gets tenure it is possible to see a remarkable change in the scholar's behavior: pre-tenure he is most of the time productive and publishing papers; after tenure he is mainly idle, with almost no publications. Therefore it is possible to identify a specialist by observing tenured professors with an outstanding lack of research interest, productivity and publications after tenure.

Thus, despite the stylized confines of our model, our conclusions are consistent with those that emphasise the *life-cycle* production nature of academic productivity. In their study of US and Canadian economic departments, Conley et al. (2013) found after six years that a substantial fraction of PhD economists had failed to publish. In the context of our model this, as we shall see, would match up with a scholar's patience or impatience. Although it may also reflect the greater delays in the publishing process in the economics profession, Conley et al. (2013).

[9] One can also think of these intervals as being informed by the norms of the scholar's department or of the profession in general.

[10] A bang-bang process in an optimal control problem that involves the possibility of jump discontinuities on the control path and corners on the state path. Such solutions can arise when the Hamiltonian is linear in the control variable; optimization will push the control variable to its prescribed limits depending on the sign of the co-state variable.

As we noted, such a lack of subsequent research productivity is one of the main criticisms of the tenure system. If this criticism is correct, academic institutions have to design the tenure system that aims at extracting all possible research productivity of the scholar during his untenured period.

The paper is organized as follows. In the following section we consider the scholar or specialist's decision in isolation. We demonstrate that his decision framework is characterized by a bang-bang research profile. He may be either producing at the prescribed maximum productivity or the minimum. The former condition appears if the scholar's wage profile is proportional to his time preference. However, since his time preference is known only to him (and not to the department), the condition has no aligning mechanism. Section 3 therefore adds in the academic department's optimal decisions. The department can set incentives in terms of wages associated with research productivity to spur scholarly productivity setting his wage growth rate proportional do the department's impatience. However this design can only succeed in making the scholar as productive as possible if he is more impatient than the department. Section 4 discusses some practical implications of the model. Finally, we conclude.

2 The Specialist's Decision

Assume that the scholar is a newly-minted Ph.D. hired by the department with a fixed tenure clock of **T** years.[11] Further assume that this new faculty member is a specialist with narrow interests and skills. Although in practice the scholar may well diversify over time, for the sake of simplicity, we assume a particular specialist who acquired all his human capital during his thesis; after that he does

[11] This is typically at or below 7 years, see the AAUP 1940 report at `www.aaup.org/report/1940-statement-principles-academic-freedom-and-tenure`. An interesting, though by no means trivial, extension of our model would be to endogenize the tenure clock evaluation period, **T**. This may be justified if some candidates are judged sufficiently outstanding as to be fast tracked; others may warrant a longer evaluation period. In our model however we take the tenure window as given, following real-world practice. However, another factor matters here since our framework is an imperfect information one: during the evaluation process, the recruiting department knows less about the candidate than the candidate does.

not evolve intellectually. Therefore his human capital and knowledge is fixed, it is a stock. During his academic years [before being evaluated for tenure at period **T**] he spends his research effort, r, transforming his Ph.D. chapters into approved academic outlets, p: for example, working papers, conference papers, research reports, book chapters, articles in peer-reviewed journals.

Equation (1) below describes the research effort as an extraction of information from the PhD dissertation; this is why the resource D decreases over time, where parameter b is the rate of extraction of one unit of research effort. In equation (2) parameter a is the number of academic papers published per unit of research effort:[12]

$$\frac{dD(t)}{dt} = -br(t) \tag{1}$$

$$p(t) = \ ar(t) \tag{2}$$

Combining both equations yields the extraction process of the thesis into published articles:

$$\frac{dD(t)}{dt} = -\frac{b}{a}p(t) \tag{3}$$

The initial stock of thesis chapters is $D\,(0)$. It is clear by the process described in equation (3) that this resource will be exhausted after the scholar publishes a number of papers based on them. So in this model the tenure track faculty member cannot forever publish the same results from his thesis. We also assume that there are natural limits, given by the scholar's own limitations, of a maximum and minimum number of papers to be published per year, respectively p_+ and p_-, where $D\,(0) \geq p_+ > p_- > 0$. Thus, the control variable, p, lies in a closed control set P, $p(t) \in P = [p_-, p_+]$.

The scholar chooses his research effort to maximize the present value of the

[12]In terms of our earlier discussion, we can think of increasingly long refereeing lags and fewer top acceptances as reflecting a fall in the a parameter.

stream of rewards:

$$\underset{r}{Max}\int_{t=0}^{\mathbf{T}}\left[w(t)-\varepsilon\right]r(t)e^{-\delta^{S}t}dt \tag{4}$$

subject to equation (3). Where $\delta^S > 0$ is the scholar's subjective rate of time preference, his impatience. The higher the time preference, the more impatient is the individual. In our context, an impatient scholar may for example be one strongly motivated to rapidly acquire a top publishing record and professional profile (e.g., listed in the *RePEc* index's top 10%). We assume the scholar's time preference is unknown by the tenuring institution. Otherwise, w is the wage and ϵ is a parameter capturing the dis-utility of research effort. We assume $w > \epsilon$.[13]

The term ϵ may also be considered to cover non-research activities: teaching, administration, professional service etc. An interesting issue is then how the scholar may optimally split effort between research and non-research activities. After tenure is granted, a scholar may substitute more departmental service for research activities, reflecting normal productivity slowing down, changing personal and departmental preferences etc. However, during the tenure period, it is likely that the candidate will be want to emphasis research output, and will be primarily judged on that.[14]

In (4) the incentives designed by the department follow a simple rule: the department pays more, the more research productive is the faculty member. Substituting equation (2) into (4) demonstrates that faculty pay is aligned with academic

[13]Note, this inequality does not preclude $\epsilon < 0$ or $\epsilon \approx 0$ (i.e., that research effort yields *positive* utility, or negligible dis-utility). But in what follows, we make the usual assumption that labor (research) effort involves dis-utility.

[14]Tenure and promotion in most universities is composed by objective criteria such as the number of publications, teaching excellence and service. Although the relative weights attached to these three areas of professional responsibility generally vary by department and/or university (see Faria et al. (2013), Harter et al. (2004); for a critique see Boyer (1990)). However, this is not to deny that subjective criteria also matter. Here, however, we focus on the arguably most important criteria of research publications.

publications, the more the academic publishes the more he earns.[15]

$$\underset{p}{Max} \int_{t=0}^{\mathbf{T}} \left[w(t) - \varepsilon\right] \frac{p(t)}{a} e^{-\delta^S t} dt \tag{5}$$

The problem of the tenure-track scholar is to maximize (5) subject to condition (3). In this problem extraction equation (3) is the state equation and the stock of Ph.D. thesis chapters, D, is the state variable, while research effort, r, [in (4)] or publication number, p, [in (5)] is the control variable.[16]

Note that the planning horizon $\mathbf{T}$, the tenure window, is known. Therefore at time $\mathbf{T}$ when the academic goes up for tenure he is expected to have exhausted all papers from his thesis: $D(\mathbf{T}) = 0$.

The Hamiltonian for the tenure track (S)pecialist is:

$$\mathcal{H}^S = \left[\left(w(t) - \varepsilon\right) e^{-\delta^S t} - \mu(t) b \right] \frac{p(t)}{a} \tag{6}$$

where $\mu(t)$ is the costate variable associated with condition (3).

Note that since equation (6) is characterized by linearity in the control variable, p, defined in a closed control set, $p(t) \in P = [p_-, p_+]$, we might expect corner (boundary) solutions to occur (e.g., Kamien and Schwartz (1991), Chiang (1992)). This means that the control is "bang-bang": it is at its minimum level while its coefficient in $\mathcal{H}$ is negative and at its maximum when its coefficient in $\mathcal{H}$ is positive.

[15] We assume that the minimum amount of academic publications is positive, $p_- > 0$. This means that even if the tenure track faculty member cannot publish his papers in peer-reviewed journals he can present them at conferences and/or publish them as working papers. This signals that he is being productive, so as to benefit from the rewards system of his department. See also Liner and Sewell (2009) and Hudson (2013) on the weighting and degrees of substitutability between different publication outlets and research evaluations in the tenuring decision.

[16] Note, we abstract from issues of the quality of journal publications. The tenure track faculty may be affiliated with a top or a low-level department, with corresponding differences in expected research quality. For quality versus quantity aspects of economists' research output see Moore et al. (2001). Conley et al. (2013) though makes the interesting point that the research rankings of top economics departments are a surprisingly poor predictor of the subsequent research rankings of their Ph.D graduates.

Accordingly, we have:

$$p(t) = \begin{cases} p_- & \text{if} \quad \frac{w(t)-\varepsilon}{b} e^{-\delta^S t} < \mu(t) \\ \\ p_+ & \text{if} \quad \frac{w(t)-\varepsilon}{b} e^{-\delta^S t} \geq \mu(t) \end{cases} \tag{7}$$

In addition, note that from the first order condition we have:

$$\frac{d\mathcal{H}^S}{dD} = \dot{\mu}(t) \tag{8}$$

Thus, $\dot{\mu}(t) = 0 \Rightarrow \mu(t) = \overline{\mu}$, where $\overline{\mu}$ is a positive constant. The condition that the Hamiltonian equals zero, combined with the condition of exhaustion of the thesis chapters at $\mathbf{T}$, when $p(\mathbf{T}) = p_+$, allow us to derive an expression for $\overline{\mu}$:[17]

$$\overline{\mu} = \frac{w(\mathbf{T}) - \varepsilon}{b} e^{-\delta^S T} \tag{9}$$

Introducing (9) into (7) yields the conditions for the maximization of the Hamiltonian:

$$p(t) = \begin{cases} p_- & \text{if} \quad w(t) < w(\mathbf{T}) e^{-\delta^S(\mathbf{T}-t)} + \varepsilon \left(1 - e^{-\delta^S(\mathbf{T}-t)}\right) \\ \\ p_+ & \text{if} \quad w(t) \geq w(\mathbf{T}) e^{-\delta^S(\mathbf{T}-t)} + \varepsilon \left(1 - e^{-\delta^S(\mathbf{T}-t)}\right) \end{cases} \tag{10}$$

The bang-bang solution in (10) resembles the optimal depletion of an exhaustible resource, like the stock of gold in a mine (e.g., Clark (1976)). This should not be a surprise given that the scholar draws his output from a finite resource, namely his Ph.D. thesis. Gold is extracted at maximum rate whenever its exogenous price exceeds the exponential price path. Likewise the mine is left dormant when the current price of gold is below the exponential price path.

Analogously, the scholar described in (10) is productive whenever his current

[17] Note in the case the resources are not fully exhausted at time $\mathbf{T}$, the value of the co-state variable will be positive but less than in (9).

wage minus the dis-utility of work, $w(t) - \varepsilon$, exceeds the exponential wage path $(w(\mathbf{T}) - \varepsilon)\, e^{-\delta^S(\mathbf{T}-t)}$, which is the current present value of his final year's wage net of dis-utility of effort. When the current wage is below $(w(\mathbf{T}) - \varepsilon)\, e^{-\delta^S(\mathbf{T}-t)}$ the researcher is at his lowest productivity level, almost idle.

It is important to stress that this bang-bang process results from two factors:

1) The scholar's research method, through the extraction of a limited resource;

2) The department's incentives, rewarding the scholar proportionally to his research productivity.

From inequalities (10) the department can derive a simple rule to extract maximum productivity from its tenure-track faculty. Consider the case in which wages grow annually at rate $\eta > 0$:[18]

$$w\,(\mathbf{T}) = w\,(t)\,(1+\eta)^{\mathbf{T}-t} \tag{11}$$

Inserting equation (11) into (10) yields:

$$p(t) = p_{+} \text{ if } w(t) \geq w\,(t)\,(1+\eta)^{\mathbf{T}-t}\, e^{-\delta^S(\mathbf{T}-t)} + \varepsilon\left(1 - e^{-\delta^S(\mathbf{T}-t)}\right) \tag{12}$$

In case of negligible dis-utility of research effort or for a sufficiently high δ^S, then $\varepsilon\left(1 - e^{-\delta^S(\mathbf{T}-t)}\right) \to 0$ and (12) simplifies to:[19]

$$\delta^S \geq \ln\,(1+\eta) \tag{13}$$

According to inequality (13) in order to make the tenure track faculty always "on", i.e., most productive at $p(t) = p_{+}$,[20] it is suffice to set the annual growth

[18]The wage growth rate may be positive due to competition among schools. In addition, that wage growth is a positive function of work-place duration is a stylized fact of labor markets in developed economies, e.g. Altonji and Williams (2005).

[19]Equivalently, $\ln\,(1+\eta) \approx \eta$ for "small" η.

[20]And which implies he applies maximum research effort through equation (2) $p_{+} = ar_{+}$.

rate of wages, η, roughly[21] equal [proportional] to the tenure track faculty's impatience, δ^S.

The problem with this simple rule is that the scholar's subjective rate of time preference, δ^S, is unknown; there is no a priori way that the department can identify the correct η to satisfy (12). Basically if the department sets a too high wage growth rate, $\eta >> \delta^S$, then the faculty member will be idle most of the time. Assuming that the tenure criteria adopted by the department is given by a minimum number of peer-reviewed publications, the candidate will be denied tenure. The tenure track scholar is thus trading off high salary growth during the tenure window against attaining tenure for the rest of his career.

This discussion demonstrates that what the *department* does is essential to explain the scholar's behavior and the path of his publications. This is the issue to which we now turn.

3 The Department's Decision

The department is assumed to behave like a firm; it has to be economically healthy to survive in order to hire and pay its faculty.[22] Its revenue is an increasing function of enrollment, and enrollment increases with the department's reputation. The latter is captured by the number of papers published by its faculty. Therefore the department's revenue can be written as:

$$R(t) = \alpha(t)\, P(t) = \alpha(t) \sum_j p_j(t) \tag{14}$$

[21] We say roughly because in the model the growth of wages is discrete, it changes once per year, while time discounting is continuous.

[22] Of course this is a simplification. Universities are non-profit organizations. According to Carlton and Perloff (1994) (p. 16): The objective of a not-for-profit firm is more complicated than that of many for profit firms, maximizing profits. There is no corresponding simple objective for a not-for-profit firm. For example, a college does not seek to maximize the difference between tuition and costs. Instead it is simultaneously concerned with the welfare of its students, faculty, administrators, alumni, and donors. Many decisions of a college involve the balancing the sometimes conflicting group interests. For university governance and decision making see McCormick and Meiners (1988), Brown (2001), Faria et al. (2012).

Where index j stands for faculty members (tenure track and tenured alike), and $\alpha(t)$ is the enrollment fee. The department's costs are given by the wage bill:

$$W(t) = \sum_j w_j(t) \frac{p_j(t)}{a_j} \tag{15}$$

The department maximizes the present value of the stream of net profits,

$$Max \int_{t=0}^{\mathbf{T}} [R(t) - W(t)] \, e^{-\delta^D t} dt \tag{16}$$

subject to the constraint,

$$\sum_j \left(\frac{dD_j(t)}{dt} \right) = -\frac{b}{a} \sum_j p_j(t) \tag{17}$$

where $\delta^D > 0$ is the department's rate of time preference. Note, (17) corresponds to the aggregate of equation (3).

Let us assume the department treats every faculty member separately. It does this to ensure it creates the correct incentives to make each faculty member as productive as possible. The (D)epartment's problem for a tenure track faculty member i is then:

$$\mathcal{H}_i^D = \left[(a\alpha(t) - w_i(t)) \, e^{-\delta^D t} - \lambda_i(t) b \right] \frac{p_i(t)}{a_i} \tag{18}$$

where λ is the costate variable associated with (17).

As in the scholar's problem this is also a bang-bang process in $p_i(t)$. Following the same steps as in equations (7) to (10) we have:

$$p_i(t) = \begin{cases} p_{i,-} & \text{if} \quad a\alpha(t) - w_i(t) < [a\alpha(\mathbf{T}) - w_i(\mathbf{T})] \, e^{-\delta^D(\mathbf{T}-t)} \\ \\ p_{i,+} & \text{if} \quad a\alpha(t) - w_i(t) \geq [a\alpha(\mathbf{T}) - w_i(\mathbf{T})] \, e^{-\delta^D(\mathbf{T}-t)} \end{cases} \tag{19}$$

The optimal solution for the department is therefore to find a wage path and an enrollment fee path consistent with the (earlier defined) scholar's optimal solution, i.e., make conditions (19) consistent with conditions (10). Therefore it has to set the wage path equal to:

$$w_i(t) = w_i(\mathbf{T})\, e^{-\delta^D(\mathbf{T}-t)} \tag{20}$$

which it aims at extracting maximum productivity from the tenure-track scholar, i.e., $p_i(t) = p_{i,+}$. Simultaneously the department sets the enrollment fee path as:

$$\alpha(t) = \alpha(\mathbf{T})\, e^{-\delta^D(\mathbf{T}-t)} \tag{21}$$

According to equation (21) the students' current enrollment fee, $\alpha(t)$, must equal the current present discounted value of the final year ($\mathbf{T}$) enrollment fee, $\alpha(\mathbf{T})\, e^{-\delta^D(\mathbf{T}-t)}$.

Note that in equation (20) if the department follows the wage growth rule in which wages for faculty member i grows annually at a constant rate $\eta_i > 0$:

$$w_i(\mathbf{T}) = w_i(t)\,(1+\eta_i)^{\mathbf{T}-t} \tag{22}$$

the department sets the wage growth rate of the tenure track faculty member i to satisfy:

$$\delta^D = \ln(1+\eta_i) \tag{23}$$

In contrast to the case with equation (12), the department knows its own impatience, δ^D, so it can easily determine the rate of salary growth for individual i, η_i, which is constant, $\eta_i = \overline{\eta} = e^{\delta^D} - 1$, and consequently the department sets the wage growth rate equal for everyone in the department: $\eta_i = \eta_j = \overline{\eta}$.[23]

By setting $\eta_i = \overline{\eta}$ the department impacts the faculty member through equation (12) and the tenure track scholar will be productive if he is more impatient

[23]Since the department has a constant discount rate the wage growth rate is constant (i.e., the same for everyone).

than the department:

$$p(t) = p_{+} \text{ if } \delta^{S} \geq \delta^{D} = \ln\left(1 + \overline{\eta}\right) \tag{24}$$

Note, the intuition (and incentive comparability) behind expression (24): the academic department (being embedded in long-lived institutions) is likely to be more patient than the typical finite-lived scholar. The candidate is eager to amass a publication record and professional profile, whilst the department is keen to identify precisely the candidate who will add the most long-lasting value to the department.

The model is closed by noticing that scholars that are impatient and satisfy inequality (24) are most likely to get tenure, since they are productive most of the time. In any firm workers get promoted on the basis of having met some standard. In academia that criterion is given by a fixed number of journal publications, P^{*}. The scholar may achieve tenure and promotion if:

$$\sum_{t} p\left(t\right) = \sum_{t} p_{+} \geq P^{*} \tag{25}$$

For the scholar who is more patient than the department and does not satisfy inequality (24), he is most of the time "off", with minimum productivity. This reduces his chances to achieve tenure since he publishes little or nothing. Recall the number of papers that can be extracted from the Ph.D. thesis is finite. Optimally the scholar will fully deplete his resources when going up for tenure. Even in the case that he does not exhaust his resources at the time of tenure, he will be productive for a limited time after being promoted and, given the department's incentives, exhaustion will happen sooner rather than later.

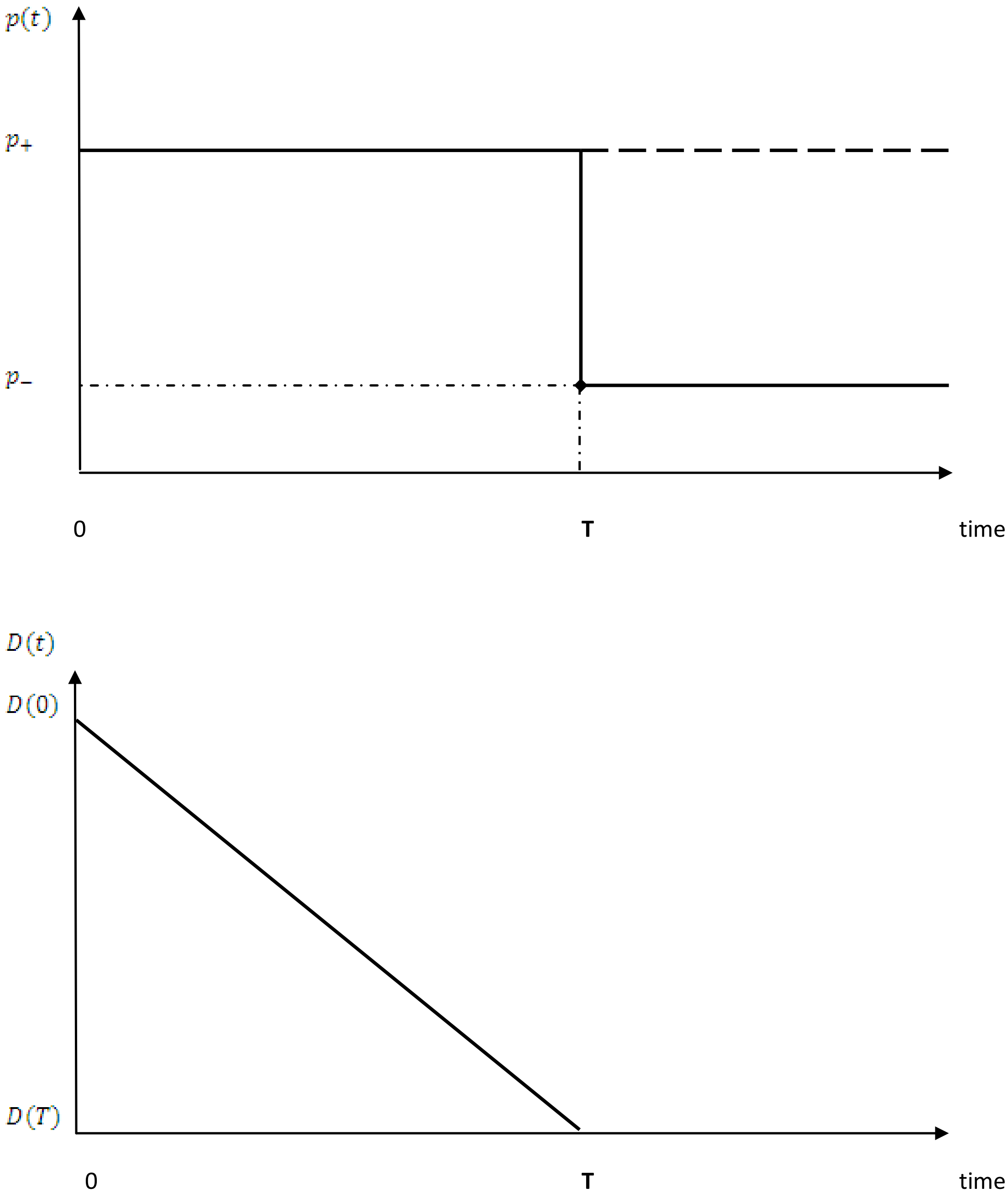
The issue resembles the *Peter Principle* (e.g., Fairburn and Malcomson (2001)) that asserts that members of an organization where promotion is based on achievement and merit will eventually be promoted beyond their ability. The principle is consistent with the observation that individuals perform worse after having received a promotion. Lazear (2004) explains the fall in productivity of tenured faculty as the result of vanishing incentives after the promotion has been granted. In the model above, however, the incentives may be in place after tenure, since condition (23) holds for every member of the department, tenured and tenure track alike, and still the scholar faculty member may never be as productive as before tenure.

The process envisaged is illustrated in **Figure 1**. The lower panel shows the depletion of the thesis chapters, at rate b. In the upper panel are three lines, corresponding to three tenure track scholars. The bold line represents the scholar whose productivity is at its maximum during the tenure-track period, but collapses to its minimum after tenure is granted at time **T**.[24] The dashed line refers to the scholar who has uniformly high productivity (for simplicity, also at p_+); thus, the attainment of tenure has no effect on his research productivity. Finally, the final dot-dashed line refers to a low productivity scholar who is denied tenure and subsequently produces zero research (i.e., drops out of research activities).

Of course attaining tenure is but one step in an academic's career path (albeit probably the single most important one). After tenure, there will be additional steps (e.g., further promotion to professor). The candidate who maintains his productivity at p_+ is clearly a viable candidate for such advancement. The tenured candidate characterized by minimum productivity, p_-, though, is clearly at a disadvantage in that regard since his type has been revealed. The un-tenured candidate of course effectively disappears from the department's assessment; he may stay on in some non-tenured role, or seek a placement at another institution. If the latter, the whole process is repeated: i.e., they enter as Assistant Professors, get a tenure window, and try to get tenure, although with greater chances since they know the game [the importance of receiving journal acceptances] and they may be in a less demanding institution.

[24]Note, despite the flat line at p_+, the scholar's *cumulative* productive is increasing linearly as the tenure window advances; this is consistent with the results of Conley et al. (2013).

Figure 1: Pre-Tenure and Post-Tenure Scenarios



4 Discussion

Now we briefly consider some practical implications of our findings. Consider the following four points. First, our simple model highlights the dangers of specialization (or at least excessive specialization) in scholarly interests. The tenure window should ideally allow the department to appreciate the candidate's evolution of interests and collaborations. If there is no such evolution, the department can infer that the scholar would make a poor candidate for tenure.

Second, in line with Conley et al. (2013), the model replicates some features of the life-cycle productivity (or lack of productivity) pattern of academics: either low acceptance rates through tenure, or rising acceptances over time as the tenure window advances, but a significant reduction in productivity *after* tenure.

Third, our model provides an ambiguous result. Departments clearly want to hire those who will enhance the standing of their department. We demonstrated the required conditions: the department must hire candidates who are sufficiently impatient (more impatient, that is, than the department). However, the department has no formal means to uncover the scholar's impatience. It is perhaps this ambiguity that partially explains the (apparent) increasing reluctance to grant tenure (recall table 1). It may also help explain the many subjective elements that underlie the tenure decision (Roche (1969)). For example, the importance given to the standing of the candidate's supervisor, of his doctoral institution, his letters of recommendation etc in filling a tenure-track position. It may then be that departments *over*weigh this information, thinking that it acts as a hedge against tenuring a non-performing scholar.

Finally, one interpretation of our results is that a *single* cut off point may be an unhelpful device for tenure evaluation. Given that the scholar already has thesis chapters available to transform into publishable articles, the period over which he may be allowed to do so need presumably be only short in length, say $\mathbf{T/2}$.[25] Once the scholar has demonstrated efficiency in performing that task, there may

[25] Of course the department can make the monitoring assessment as frequent as possible (e.g., annual), however the department has a [time] cost associated to it.

be a second phase (also, say, of $\mathbf{T/2}$ length) during which the scholar is expected to show continued success in research. After this second period, and thus exactly as before at $\mathbf{T}$, tenure may be considered with fewer risks involved. Indeed, our model provides a justification for this procedure.[26]

5 Conclusions

This paper has examined how scholars may obtain tenure. It does so with some simplifying assumptions. Our tenure track faculty are individuals with narrow intellectual interest. They are specialized in one technical field after obtaining a Ph.D. and do not evolve intellectually. When employed by an academic institution, the scholar's research productivity consists in transforming his thesis chapters into publishable papers. The dynamic model examines how a department that hired such scholars provides incentives to make them as research productive as possible.

The model also examines how such scholars react to these incentives. The surprising result is that whenever they go up for tenure, their research productivity and journal publications paths are characterized by a bang-bang solution, i.e., sometimes they are "on", working on their research projects at maximum effort, and sometimes they are off, doing almost no work.

The model shows that the department can set incentives in terms of wages associated with research productivity to spur scholarly productivity setting his wage growth rate proportional do the department's impatience. However this design can only succeed making the scholar as productive as possible if he is more impatient than the department.

The impatient scholar is more likely to get tenure, if the department's criterion to grant tenure is based on the number of publications. The impatient scholar spends most of the time with his research productivity at maximum. And as for the patient scholar who is idle most of the time (since his rate of time preference is

[26] An alternative to tenure is for candidates to have a screening period where some scholars are terminated and others are reappointed for a *fixed term* rather than granted permanent tenure.

smaller than the department's), he is less likely to secure tenure. The consequence of our theory is that the scholar displays remarkable change in research behavior. Prior to obtaining tenure he is as productive as possible most of the time. After tenure he is idle.

Accordingly our paper brings a novel perspective to the tenure debate. It offers a micro-founded framework to analyze one of its key issues: i.e., that after tenure scholars may become unproductive. Our framework, note, is entirely independent of the most common explanation for academic career productivity – namely, the natural slowing down of aging scholars. We have further suggested that the key resolving mechanism lies in the scholar's impatience as against that of the tenuring department and its remuneration policies.

Note, also the potential generality of our framework. As we remarked upon in the Introduction, many professions are characterized by tenure (or tenure-type) systems. Many other professions, though, are deliberately characterized by its absence. Consider politics: in some systems Presidents or Prime Ministers and Senators and/or Parliamentarians have fixed term limits, in others cases political longevity is open-ended (subject to electoral success). It is therefore an interesting point as to whether there would (controlling for other relevant factors) be significant differences in effort made by political agents to enact favored reforms depending on the degree of tenure faced. We leave these questions open for future research.

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