

Evolving Standards for Academic Publishing: A q - r Theory

Glenn Ellison¹

Department of Economics
Massachusetts Institute of Technology

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Abstract

This paper develops a model of evolving standards for academic publishing. It is motivated by the increasing tendency of academic journals to require multiple revisions of articles and by changes in the content of articles. Papers are modeled as varying along two quality dimensions: q and r . The former represents the clarity and importance of a paper's main ideas and the latter its polish. Observed trends are regarded as increases in r -quality. A static equilibrium model in which an arbitrary social norm determines how q and r are weighted is developed and used to discuss comparative statics explanations for increases in r . The paper then analyzes a learning model in which referees (who have a biased view of the importance of their own work) try to learn the social norm from observing how their own papers are treated and the decisions editors make on papers they referee. The model predicts that social norms will gradually but steadily evolve to increasingly emphasize r -quality.

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Glenn Ellison
Department of Economics
Massachusetts Institute of Technology
50 Memorial Drive
Cambridge, MA 02142-1347

1 Introduction

I encourage potential readers of this paper to first put it down for two minutes and thumb through a thirty- or forty-year-old issue of an economics journal. I anticipate that this will convey much better than I can how dramatically economics papers have changed over the last few decades. Papers today are much longer.¹ They have longer introductions.² They have more sections discussing extensions of their main results. They have more references.³ The process by which papers get published has also changed dramatically. Around 1960 the *Quarterly Journal of Economics* reserved the “revise-and-resubmit” option for five or so special cases per year. In the early 1970’s most journals’ processes still let authors submit their papers, receive reports, make revisions and get a final acceptance within about nine months. Today extensive revisions are the norm and getting an acceptance takes 20 to 30 months at most top journals.⁴ Many other academic disciplines have had similar experiences.

While the changes in academic journals are widespread and dramatic, they have received little attention. Perhaps this reflects that the changes have occurred gradually and that researchers in each field see only a small part of the overall picture.

In this paper I develop a model to organize the observed trends and help us think about potential explanations. My central premise is that we can usefully regard academic papers as differing along two quality dimensions: q and r . I think of q as reflecting a paper’s main ideas and r as representing other aspects of quality like thoroughness and polish. I think of the various changes noted above as different aspects of a single phenomenon — an increase in the r -quality of published papers. I first develop an equilibrium model of time

¹Ariel Rubinstein’s 1982 *Econometrica* article, “Perfect Equilibrium in a Bargaining Model,” for example, is shorter than the average note in *Econometrica* in 2000 (if one accounts for the type sizes).

²For example, Amartya Sen’s “The Impossibility of a Paretian Liberal” and two other papers in the January-February 1970 issue of the *Journal of Political Economy* had one paragraph introductions. No introduction in the February 2000 *JPE* was shorter than seven paragraphs and two were longer than Sen’s entire paper.

³An extreme example here is Michael Spence’s 1973 *QJE* paper “Job Market Signaling.” It contains two references. While my anecdotes all relate to classic papers, old journals also contain many derivative papers making N^{th} order contributions to long forgotten literatures. These also look very different from today’s papers.

⁴The one exception is the *QJE* where it takes about 13 months. See Ellison (2000) for much more data on the duration of review process.

allocation and quality standards and use it to discuss what might cause such an increase. I then develop a dynamic learning model in which economists struggle to reconcile the high standards to which they are being held with the mediocrity they see in journals (This occurs in part because economists have biased views of the quality of their own work.) The model predicts that social norms will evolve gradually to emphasize r -quality.

I begin in Section 2 with a quick look at some data on the form of papers and the length of the review and revision process in a number of disciplines.

Section 3 describes a static equilibrium model of the journal publishing process. A continuum of economists are endowed with one unit of time in which to write one paper for the one journal in the profession. Papers are described by their position along two quality dimensions, q and r . I interpret the q dimension as reflecting the clarity and importance of the main results of the paper, and the r dimension as reflecting various other aspects of quality (generality, robustness checks, extensions, etc.) that are typically improved in revisions and when authors “polish” papers prior to the submission. The main decision economists make is how to divide their time between the developing new ideas and working on r quality. A commonly understood social norm determines how the quality dimensions are weighted.

I analyze the static model in Section 4. For a range of parameter values the model produces a reasonable outcome. Papers initially submitted to the journal can be divided into three groups. Papers with the lowest q are determined to be of sufficiently low interest that no feasible revision could make them acceptable. They are not revised. A second set of papers with intermediate q 's are marginal. These papers are revised to the greatest extent possible, but only some become acceptable. Finally, papers with a sufficiently high q will be publishable even if they achieve a somewhat lower r . The authors of these papers are always able to meet the standard that is set for them with a revision.

I make two main observations about the static model. First, a continuum of social norms are possible. If the community agrees that q -quality is very important, then authors will spend most of their time developing main ideas. If r -quality is very important, then authors spend very little time on ideas and focus on revisions. Nothing in the model prevents either extreme or something in the middle from being an equilibrium. Second, the marginal papers

that fall just short of being accepted are relatively low in q -quality and relatively *high* in r -quality relative to the set of resubmitted papers. This is a consequence of the assumption that a paper's q -quality is developed first and revisions later increase r .

While the model makes clear that a number of equilibrium comparative statics explanations could be given for increases in r -quality, such explanations may not work well in practice. The observed changes in economics and other fields are very large. Accounting for them requires either a large change in some exogenous variable or a high sensitivity of the outcome to an exogenous variable. My impression from the empirical work I've done is that the economics profession has not changed much over the last thirty years. (Ellison, 2000) Equilibrium explanations are also hard to reconcile with editors' comments that changes were not planned or desired. I take these difficulties as motivation for exploring evolutionary explanations — to account for the observed changes such an explanation would only need to provide a good reason to think that each year papers will be a paragraph longer and require a couple weeks more to revise than the year before.

Section 5 describes a dynamic learning model. The main actors in the model are the journal's referees (who are also the authors). The referees are not self interested. They simply try to apply the prevailing standards of the profession in weighting q -quality and r -quality and in proposing a set of improvements that would bring a paper up to the publication threshold. Referees learn the prevailing standards from two sources: observations of what revisions they are asked to make and observations of whether editors eventually decide to accept or reject papers they have refereed.

Editors are not an active force in the model. They simply fill the journal's slots by accepting the fraction τ of papers with the highest average quality (weighted according to the then prevailing norm). I view this as a model of a busy editor. Making referees the driving force is also consistent with editors' comments that they abhor the trend toward fifty page papers with myriad extensions and wish that authors would just concisely explain what ideas they have.

Section 6 discusses the dynamic model with no overconfidence bias. All of the equilibria of the static model are steady-states. I note that *if* referees try to hold authors to a standard that is infeasibly high, then economists will both realize that overall quality stan-

dards are lower than they had thought *and* conclude that r -quality must be relatively more important than they had thought. The latter inference is made because the submarginal papers that are unexpectedly accepted are relatively low in q and relatively high in r .

Section 7 adds in the assumption that economists are biased and think their work is slightly better than it really is.⁵ The former steady-states of the model are destabilized as referees try to hold others to the higher standard that they perceive is being applied to their own papers. Standards can not stray far from the equilibrium set — referees would see editors accepting many papers they strongly recommended against and this would overwhelm the ϵ bias. What happens instead is that referees perpetually try to hold authors to a standard that is slightly too high. The observation of the previous section about how economists rationalize standards that are too high still applies. The result is a gradual evolution of social norms to increasingly weight r -quality. The slow steady form of the dynamics makes them a candidate for explaining observed trends. In the long run the process stops short of papers having no q -quality at all, because the dynamics change once no paper's idea is good enough to make its acceptance a sure thing.

There has been little related theoretical work on the dynamics of standards. The most notable is Sobel's (1998) analysis of a model in which a series of candidates work to obtain admission to a club. Judges have heterogeneous tastes. The focus is on how different voting rules lead to rising, falling or fluctuating standards.

The fact that I have not followed the current trend and given this paper an overly general title and a seven page introduction should not be taken to indicate that there are not broader lessons to be learned from it. There are all kinds of social norms, e.g. standards for politeness, standards for language and violence on television, hazing at fraternities, hours worked by young doctors and lawyers, years spent in higher education, distributions of grades, etc. Many of these norms have commonly perceived trends, but other than the

⁵In the psychology literature this is referred to as an overconfidence bias. An often discussed example is Svenson's (1981) finding that about 90 percent of the U.S. college students in his study estimated themselves to be safer (and more skillful) at driving than the median subject. Psychologists have reported that experts in many fields are overconfident in assessing their own ability to answer questions. Lichtenstein, Fischhoff and Phillips (1982) provide a nice (but early) survey. Overconfidence is frequently mentioned in finance to motivate the existence of agency problems and to justify the actions of noise traders as in De Long et al (1990). Odean (1998) is a notable recent contribution with a detailed summary of psychology and finance papers on overconfidence. Rabin (1998) discusses a number of other psychological biases and their relevance to economics.

literature on fashion cycles, e.g. Karni and Schmeidler (1990) and Pesendorfer (1995), most of the existing literature on social norms is static. I do not want to draw conclusions about other norms from my results. My view is that one would need to analyze each application separately and think about how the norm is learned to assess whether a drift should be expected and in what direction.

On a theoretical level, the paper's innovation is to note that one can produce a model that explains a long gradual trend by making a slight perturbation to a model with a continuum of equilibria. In an early presentation of this paper Robert Barro asked a penetrating question: 'so are you trying to tell us that you're going to explain a thirty-year trend by saying that we've been out of equilibrium the whole time?' My answer is "Yes!" I hope to convince readers that models of the type I introduce make such arguments possible.

2 Some data from various disciplines

Table 1 provides some statistical evidence on how the form of an academic article has changed. The table lists the average page length and the average number of references for articles in top journals in a number of disciplines. Economics papers are roughly twice as long as they were twenty five years ago and have about twice as many references. In almost all fields papers seem to be longer now than in 1975. The increases are more moderate in the sciences. Likewise with the exceptions of law and history, articles now tend to have more references. While economics has experienced substantial growth it has a long way to go to catch many social sciences in this dimension.

Table 2 provides some evidence on how long it takes to review papers and on how extensively they are revised for publication in a number of fields. In almost every case it takes longer to get a paper accepted now than it did in 1975. While *Econometrica* and the *Review of Economic Studies* have the most drawn out publication processes among the listed journals, similar trends are visible in computer science, psychology, statistics, linguistics and finance, and I've been told that many rounds of revisions are also the norm at the top journals in marketing, political science, and a number of other social sciences. A slowdown is also visible in some sciences, but the time scale is completely different.

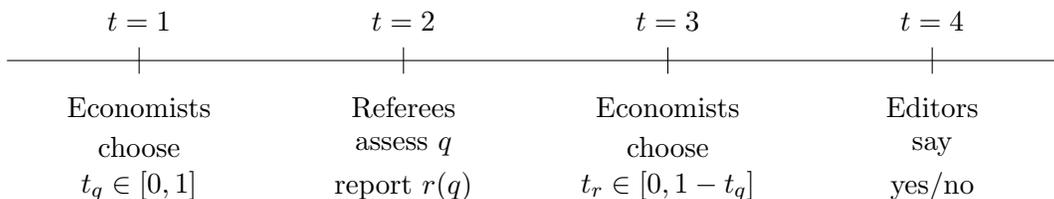
3 The static model

In this section I describe a simple static model of academic publishing. The main actors in the model are a continuum of economists (of unit mass). Each economist is endowed with one unit of time and may write one paper. There is one economics journal that publishes a mass τ of papers with $0 < \tau < 1$. Economists preferences are lexicographic in publications and leisure time, i.e. they attempt to maximize the probability of publishing an article in the journal; holding the expected number of publications fixed they prefer more leisure to less.

Papers can be fully described by two dimensions of quality, q and r . The q -quality dimension is intended to reflect the inherent importance, interest, clarity etc. of the main ideas of the paper. The r -quality dimension is intended to reflect additional aspects of quality that authors improve when they are asked in revisions to improve and tighten a paper's exposition, to make clear relationships to other papers in the literature, to generalize theoretical results, to check the robustness of empirical results, to extend the analysis to consider related questions, etc.

Social norms for evaluating papers are assumed to be common and commonly known in the community. Under the (α, z) -social norm, papers are regarded as worth of publication if and only if $\alpha q + (1 - \alpha)r \geq z$. Note that the parameter α may reflect two different value judgements by the profession. In addition to reflecting what people think makes a paper valuable, it can also reflect what people think authors should be required to do. For example, a referee might argue that while he feels that a particular high q low r paper is "better" than the marginal paper in a journal, it should still be rejected because the good idea does not excuse the author's failure to make r improvements required of everyone else.

The timeline of the model is illustrated below. While the model is described as a four step process with three groups of players, at the moment the authors are the only ones acting in a nonmechanical way.



In the first stage of the model, authors choose the fraction $t_q \in [0, 1]$ of their time to devote to thinking up and developing the main ideas of the paper. The result is a paper of q -quality $q \sim F(q|t_q)$. Assume that F is continuously differentiable in t_q and for each t_q , F has an everywhere positive density $f(q|t_q)$ on the interval $[0, m(t_q)]$ (with $m(t_q) > 0$ being possibly infinite). Natural specifications will have the q distribution increasing in t_q . For example, q might be assumed to be uniformly distributed on $[0, t_q]$ or exponentially distributed with mean t_q .

In the second stage of the model authors submit their papers to the journal. The journal's referees correctly assess the quality q of the paper and report that it will be acceptable for publication if and only if authors are able to revise it and achieve an r -quality of at least $r(q)$ as defined by $\alpha q + (1 - \alpha)r(q) = z$. In practice one can think of $r(q)$ as a measure of the number of improvements referees ask for in their reports and the difficulty of the tasks.

In the third stage authors choose the amount of time $t_r \in [0, 1 - t_q]$ to spend on revisions. The production of r -quality is again a random process. Specifically, assume that $r = h(t_r) + \eta$, where η is a random variable uniformly distributed on $[0, \sigma]$ with $\sigma > 0$. Assume that the production of revisions is a decreasing returns activity with $h(0) = 0$, $h' \geq 0$ and $h'' < 0$. To ensure that time will be allocated to both dimensions of quality I assume also that $h'(0) = \infty$, and $h'(1) = 0$.

In the fourth stage, editors accept the fraction τ of papers for which $\alpha q + (1 - \alpha)r$ is highest for publication.

An *equilibrium* of the model is a quadruple, $(\alpha, z, t_q^*, t_r^*(q))$ such that t_q^* and $t_r^*(q)$ are chosen to maximize the probability that $\alpha q + (1 - \alpha)r \geq z$ (and are as small as possible if there are multiple choices that yield the same probability of publication) and such that the fraction of papers with $\alpha q + (1 - \alpha)r \geq z$ is exactly τ . I will refer to (α, z) as a *consistent*

social norm if there exist choices of t_q and $t_r(q)$ for which $(\alpha, z, t_q, t_r(q))$ is an equilibrium.

4 Analysis of the static model

In this section I analyze the model described in the previous section. I wish to highlight two main observations. First, many different social norms are possible. Second, the marginal accepted papers tend to have relatively low q -quality and relatively high r -quality in the universe of published papers.

4.1 Characterization of equilibrium

The analysis of the equilibrium is a straightforward backward induction argument. Consider an equilibrium $(\alpha, z, t_q^*, t_r^*(q))$. Because of the lexicographic preference for publications over leisure, at $t = 3$ authors will devote all of their remaining time to improving their paper's r -quality unless the paper is sure to be rejected anyway or is sure to be accepted even if less time is devoted to revisions. As a result we have,

Proposition 1 *In any equilibrium of the model, let $\underline{q} = (z - (1 - \alpha)(h(1 - t_q^*) + \sigma))/\alpha$ and $\bar{q} = (z - (1 - \alpha)h(1 - t_q^*))/\alpha$. Then, $\underline{q} < \bar{q}$ and*

$$t_r^*(q) = \begin{cases} 0 & \text{if } q < \underline{q}, \\ 1 - t_q^* & \text{if } \underline{q} < q \leq \bar{q}, \\ h^{-1}((z - \alpha q)/(1 - \alpha)) & \text{if } \bar{q} \leq q. \end{cases}$$

(For this proposition, define $h^{-1}(x) \equiv 0$ if $x < 0$.)

Note that \underline{q} may be less than zero and \bar{q} may be greater than the upper bound of the support of q . Hence, it is possible that either of the extreme cases may not arise for particular parameterizations of the model.

In the first stage, the time t_q allocated to trying to develop the main ideas for a paper will be chosen to maximize the probability of eventual publication. Write $G(z; t)$ for the probability that $\alpha q + (1 - \alpha)r$ is at most z when $t_q = t$ and t_r is chosen optimally as in the above proposition. Note that this probability is the same as it would be if t_r was simply set equal to $1 - t_q$. Hence,

$$G(z; t) = \int_{q=0}^{\min(m(t), \frac{z - (1 - \alpha)h(1 - t)}{\alpha})} \max\left(1, \frac{z - \alpha q - (1 - \alpha)h(1 - t)}{\sigma}\right) f(q|t) dq$$

Note that G is uniformly continuous in z and t . It is strictly increasing in z whenever $G(z; t)$ is strictly between zero and one. Write $G^{-1}(p; t)$ for the inverse of this function for a fixed t . The equilibrium time allocation is easily described by

Proposition 2 *In the first stage of any equilibrium, the time allocated to developing q -quality satisfies*

$$t_q^* \in \text{Argmax}_t G^{-1}(1 - \tau; t).$$

Proof

In equilibrium, each economist's paper is accepted with probability τ . Hence, z must satisfy $G(z; t_q^*) = (1 - \tau)$. If t_q^* does not belong to $\text{Argmax}_t G^{-1}(1 - \tau; t)$, then any t which does maximize that expression has $G^{-1}(1 - \tau; t) > G^{-1}(1 - \tau; t_q^*) = z$. Because G is strictly increasing in z whenever $0 < G(z; t) < 1$, this implies that $G(z, t) < G(G^{-1}(1 - \tau; t)) = \tau$, which contradicts the optimality of t_q^* .

QED.

4.2 Some examples

Figure 1 illustrates the distribution of paper qualities in a “typical” equilibrium — in this case generated by assuming that $\tau = 0.3$, q is uniformly distributed on $[0, t_q]$, the technology for r production is $h(t_r) = \sqrt{t_r} - t_r/2$ with $\sigma = 0.2$, and the social norm for judging papers has $\alpha = 0.5$ and $z \approx 0.504$.

For these parameters, the equilibrium effort allocated to q production turns out to be $t_q^* \approx 0.826$. All three possible outcomes of a submission occur. Authors of papers with q -quality less than $\underline{q} \approx 0.48$ realize that their papers have no chance of becoming acceptable and do not attempt to revise them. Authors of papers with $q \in (\underline{q}, \bar{q}) \approx (0.48, 0.68)$ devote as much time as possible to revising (setting $t_r = 1 - t_q^* \approx 0.174$) and have their papers accepted with probability strictly between zero and one. Authors of papers with quality $q \in [\bar{q}, m(t_q) = t_q^*] \approx [0.68, 0.83]$ do the minimal revision necessary to ensure that their papers will be accepted with probability one.

The figure shows the outline of the support of the equilibrium distribution of paper qualities in (q, r) -space. Paper qualities are distributed with a constant density within

these regions. Papers in the lower left box are those for which authors set $t_r = 0$. These papers are never accepted. The upper right region is divided into a triangle of papers that are revised then rejected and a trapezoid of papers that are accepted. The mass of papers in this upper region is, of course, τ .

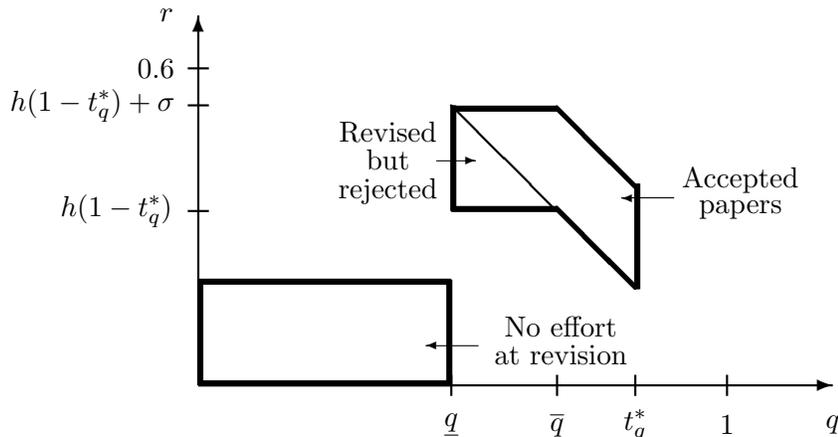


Figure 1: The equilibrium distribution of paper qualities in a “typical” equilibrium: $\tau = 0.3$, $q \sim U[0, t_q]$, $h(t) = \sqrt{t} - t/2$, $\sigma = 0.2$, $\alpha = 0.5$, $z \approx 0.504$.

The form of the equilibrium seems to reflect fairly well the functioning of an economics journal. One observation I’d like to make is that the “marginal” rejected papers have relatively low q -quality compared to the pool of accepted papers — they all have $q \in [q, \bar{q}]$. The marginal rejected papers are not relatively low in r -quality. Their authors have spent as much time as possible revising and achieved r -qualities that are on average superior to those of accepted papers.

While I think that the case illustrated above is the primary one of interest and subsequent arguments focus on it, the equilibrium can take other forms for different parameter values. Most notably, when α is sufficiently small (i.e. q -quality is of little importance) all authors set $t_r = t_q^*$ — there will always be some chance that any idea, no matter how vacuous, can be developed into a publishable paper and no paper’s idea is good enough to make its eventual acceptance a sure thing. The following proposition formalizes this observation. Figure 2 graphs the equilibrium distribution of paper qualities and the acceptance and rejection regions for such a case: $q \sim U[0, t_q]$, $h(t_r) = \sqrt{t_r} - t_r/2$, $\sigma = 0.2$, $\alpha = 0.2$ and

$z \approx 0.532$.

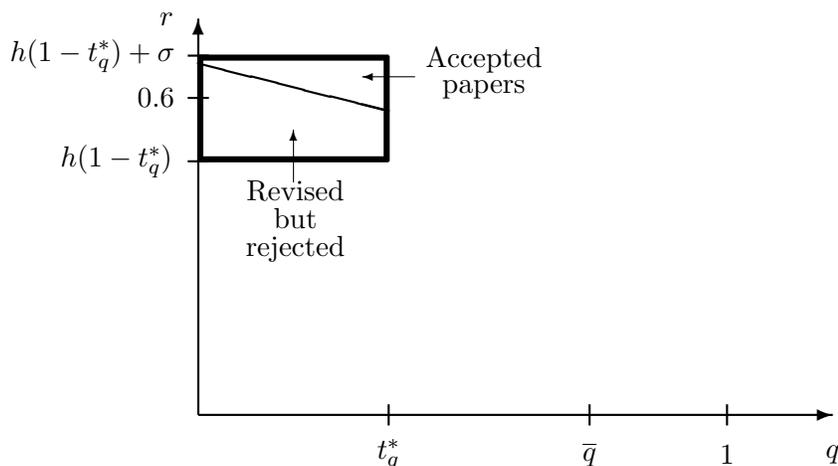


Figure 2: An example of the equilibrium quality distribution in a “low α ” equilibrium: $\tau = 0.3$, $q \sim U[0, t_q]$, $h(t) = \sqrt{t} - t/2$, $\sigma = 0.2$, $\alpha = 0.2$, $z \approx 0.532$.

Proposition 3 *Suppose that the upper bound of the q -distribution, $m(t_q)$, is finite and uniformly bounded for all $t_q \in [0, 1]$. Then, there exists $\bar{\alpha} > 0$ such that for all $\alpha \in (0, \bar{\alpha})$, $t_r^*(q) = 1 - t_q^*$ for all $q \in [0, m(t_q^*)]$, i.e. all papers are revised to the greatest extent possible and no paper achieves a level of q -quality sufficient to ensure that it will be accepted with probability one.*

Proof

To see that $q \leq 0$ note that if a paper with $q = 0$ is revised to the greatest extent possible and gets the best possible draw on r -quality its overall quality will be $(1 - \alpha)h(1 - t_q^*) + \sigma$.

In equilibrium,

$$\begin{aligned} \text{Prob}\{\alpha q + (1 - \alpha)r \geq (1 - \alpha)(h(1 - t_q^*) + \sigma)\} &\leq \text{Prob}\{r \geq h(1 - t_q^*) + \sigma - \frac{\alpha}{1 - \alpha}m(t_q^*)\} \\ &\leq \frac{\alpha}{1 - \alpha}m(t_q^*)/\sigma \rightarrow 0 \text{ as } \alpha \rightarrow 0. \end{aligned}$$

For α sufficiently small the expression is less than τ , and hence there is a positive probability of the paper with $q = 0$ being acceptable.

Similarly, to see that $q > m(t_q^*)$ note that if a paper with q -quality is revised to the greatest extent possible but gets the worst possible draw on r -quality its overall quality

level is $\alpha m(t_q^*) + (1 - \alpha)h(1 - t_q)$ and

$$\begin{aligned} \text{Prob}\{\alpha q + (1 - \alpha)r \geq \alpha m(t_q^*) + (1 - \alpha)h(1 - t_q^*)\} &\geq \text{Prob}\{r \geq h(1 - t_q^*) + \frac{\alpha}{1 - \alpha}m(t_q^*)\} \\ &\geq 1 - \frac{\alpha m(t_q^*)}{\sigma(1 - \alpha)} \rightarrow 1 \text{ as } \alpha \rightarrow 0. \end{aligned}$$

Hence, for any $\tau < 1$ the probability that a paper with q -quality $m(t_q^*)$ fails to be among the best τ is strictly positive if α is sufficiently small.

QED.

Some of the results I'll give later will depend on the form of the equilibrium. To simplify the statements of these results I will give the forms pictured in the figures (and a couple of other forms) names.

Definition 1 *I will say that an equilibrium is “typical” or has the typical form if $0 < \underline{q} < \bar{q} < m(t_q^*)$ and $r(m(t_q^*)) > 0$. An equilibrium has the “low α ” form if $\underline{q} < 0 < m(t_q^*) < \bar{q}$. It has the “somewhat low α ” form if $0 < \underline{q} < m(t_q^*) < \bar{q}$. It is of the “high α ” form if $0 < \underline{q} < \bar{q} < m(t_q^*)$ and $r(m(t_q^*)) < 0$.*

The somewhat low α form is similar to the low α form, with the only difference being that in the former authors of the lowest q papers do not revise their papers. The high α form is similar to the typical form, but the highest q papers are so good that $r(q)$ is negative, i.e. referees tell the authors that even if they revised the paper to make it worse it would still be publishable. The authors of these papers obviously exert no effort on revisions and have their papers accepted with quality to spare. In the model with $q \sim U[0, t_q]$, $h(t) = \sqrt{t} - t/2$, $\sigma = 0.2$ and $\tau = 0.3$ the equilibrium has the low α form for $\alpha \in (0, 0.2285)$, the somewhat low α form for $\alpha \in (0.2286, 0.3363)$, the typical form for $\alpha \in (0.3364, 0.5869)$ and the high α form for $\alpha \in (0.5870, 1)$. In other specifications for the model the equilibrium can take on other forms. For example, if the distribution of q is unbounded (or τ is large) we will simultaneously see papers of the lowest q -quality being resubmitted and papers of the highest q -quality being accepted with no revisions.

4.3 The multiplicity of consistent social norms

In the model described above not all social norms are consistent. If there is only room in the journal for a small fraction of papers, then the quality threshold z must be high.

This, however, is really the only constraint. Nothing in the model restricts the weight the community places on q -quality versus r -quality. There are a continuum of consistent social norms with any α being possible. The following proposition gives a formal statement to this effect, and Figure 3 graphs the set of consistent social norms for the model with $q \sim U[0, t_q]$, $h(t) = \sqrt{t} - t/2$, $\sigma = 0.2$ and $\tau = 0.3$.

Proposition 4 *In the model described above, for any $\alpha \in [0, 1]$ there exists a unique $z^*(\alpha)$ such that $(\alpha, z^*(\alpha))$ is a consistent social norm.*

Proof

For any fixed α , let $G(z; t)$ be the CDF of $\alpha q + (1 - \alpha)r$ as above. Let $H(z) = \inf_t G(z; t)$. Because G is uniformly continuous, t is chosen from a compact set and $\lim_{z \rightarrow \infty} G(z; t) = 1$ for all t , H is continuous with $H(0) = 0$ and $\lim_{z \rightarrow \infty} H(z) = 1$. Hence there is a solution $z^*(\alpha)$ to $H(z) = 1 - \tau$. $(\alpha, z^*(\alpha))$ is a consistent social norm.

It is not possible for both (α, z) and (α, z') to be consistent social norms with $z < z'$. In that case, an agent setting t_q equal to the the equilibrium choice under the (α, z') norm would surpass the z threshold with probability greater than τ .

QED.

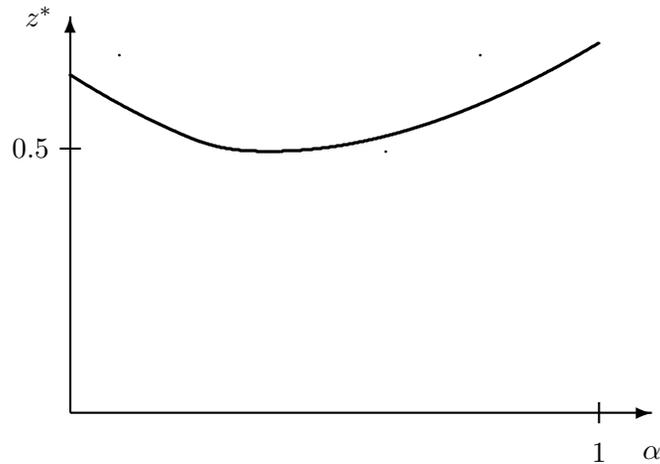


Figure 3: Consistent social norms (α, z) in the model with $q \sim U[0, t_q]$, $h(t) = \sqrt{t} - t/2$, $\tau = 0.3$, and $\sigma = 0.2$.

4.4 Explanations for observed increases in r -quality

My view of the trends in economics papers mentioned in the introduction is that they can all be thought of as reflections of an increase in the r -quality of published papers. The model makes clear that a number of different explanations for the change are possible.

The explanation I focus on in the latter half of this paper is that the r -quality of published papers will increase if α decreases, i.e. if social norms shift to place relatively less emphasis on q -quality and relatively more emphasis on r -quality. This raises the r -quality of published papers for two reasons: economists react by allocating more of their time to producing r -quality; and when choosing from the pool of resubmitted papers the journal places more emphasis on r -quality.

Other plausible explanations do not require a change in social norms for trading off q and r . One is that the technologies for producing q and r may have shifted over time. For example, one could argue that economists have begun to exhaust the set of all possible ideas and model this as a change in $F(q|t_q)$ that reduces the marginal benefit of t_q . Similarly, one could argue that advances in computer technology or accumulated knowledge now allow authors to produce more r -quality per unit time. A second potential explanation is that publishing in the top journals may have become more competitive. We might think of the growth of the profession and other factors as equivalent to a decrease in τ , and this might raise quality standards in both dimensions.⁶

The latter explanation is not straightforward, so I'll discuss it further. Intuitively, reducing τ has two effects. First, it allows the journal to be more selective when choosing from the pool of resubmitted papers. Second, it affects authors' time allocation decisions. If authors react to increased competition by gambling on bold projects that require a lot of t_q , the second effect could offset the first and make the overall effect of competition on r -quality ambiguous.

Formally, I should note first that nothing in the assumptions so far guarantees that $G^{-1}(1-\tau; t_q)$ (which plays the role of the economists' objective function when t_q is selected)

⁶Ellison (2000) notes that by most measure the growth in the profession over the last 30 years appears to be moderate, but that decreases in the number of articles published by some top journals and an increase in the relative status of the top journals may also have contributed to an increase in competition.

is quasiconcave. If, for example, $q \sim U[0, kt_q^n]$ with $n > 1$, then the production of q -quality would involve increasing returns. In some cases, both both 0 and some higher value of t_q will be local optima and t_q^* will change discontinuously in the parameters. To provide as simple a discussion as I can of the potential effects of τ on r -quality, I will avoid such complications by just assuming that $F(q; t)$ is such that t_q^* is the unique solution to $\frac{\partial G}{\partial t}(z^*(\alpha, \tau); t) = 0$ among values of t for which $G(z^*(\alpha, \tau); t) < 1$ and that the probably of achieving the standard is strictly concave at the optimum, i.e. $\frac{\partial^2 G}{\partial t^2}(z^*(\alpha, \tau); t_q^*) > 0$.

Recall that $t_q^*(\tau)$ solves

$$\frac{\partial G}{\partial t}(z^*(\tau); t_q^*(\tau)) = 0.$$

Differentiating with respect to τ gives

$$\frac{\partial^2 G}{\partial z \partial t}(z^*(\tau); t_q^*(\tau)) \frac{dz^*}{d\tau} + \frac{\partial^2 G}{\partial t^2} \frac{dt_q^*}{d\tau} = 0.$$

z^* is always decreasing in τ and we have assumed that $\frac{\partial^2 G}{\partial t^2}$ is positive. Hence, t_q^* will be decreasing in τ if $\frac{\partial^2 G}{\partial z \partial t}(z^*(\tau); t_q^*(\tau)) < 0$. To think about the sign of this derivative note that $\frac{\partial G}{\partial z}(z; t_q)$ is the density of the overall quality distribution. If the q distribution becomes more spread out when authors spend more time thinking of new ideas and the production of r -quality is a more deterministic process in which increases in t_r only shift the mean r -quality (as we've assumed), then the natural outcome is for the density to be decreasing in t_q , in which case the $\frac{\partial}{\partial t} \frac{\partial G}{\partial z}$ is negative. In this case, t_q^* will increase as τ decreases, and the overall effect of τ on r -quality may be ambiguous.

For a more direct intuition note that t_q^* reflects authors setting α times the effect of t_q on q -quality equal to $(1 - \alpha)$ times the effect of t_r on r -quality conditional on their luck being such that their paper is marginal for the journal. When the journal is highly nonselective, this is conditioning on getting a very bad draw from the q distribution. When the journal is extremely selective, the conditioning is on getting nearly as a good a draw as possible on q . With a functional form like $F(q|t_q) \sim U[0, t_q]$, the higher percentiles of the q distribution are more sensitive to t_q investments. Hence the return to t_q is greater when one conditions on the paper being marginal for a more selective journal.

Figure 4 illustrates the effects of changes in τ on time allocation and quality in a model with $q \sim U[0, t_q]$, $h(t) = \sqrt{t} - t/2$, $\sigma = 0.2$, and $\alpha = 0.5$. The left panel shows that t_q^* is

monotonically decreasing, i.e. t_q^* increases as the journal becomes more competitive.⁷ The right panel shows the effect of τ on the mean q - and r -quality of the published papers. The relationship between τ and r -quality is nonmonotonic. At some points the effect of τ on t_q^* dominates, while at others the effect of journal selectivity dominates.

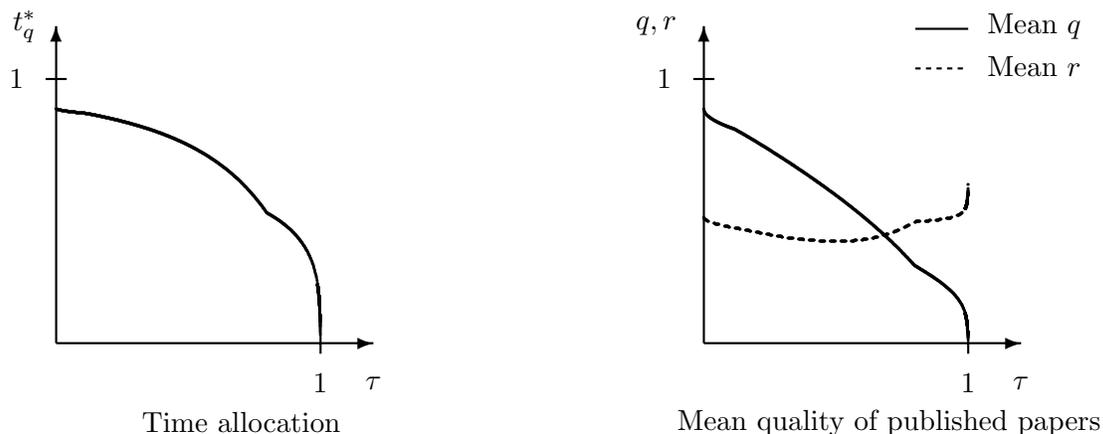


Figure 4: Effect of journal selectivity on time allocation and observed paper quality

5 A dynamic model of evolving norms

The static model above has a continuum of equilibria corresponding to different social norms. In this section I describe a dynamic model of the evolution of norms. The model involves a population of author-referees who are trying to learn and apply the profession’s standards. In contrast to what one might think when one hears the term “learning model”, I will not model agents as arriving with different beliefs and examine whether there is convergence to a common belief. Instead, the model will be constructed so that agents will have common beliefs at every point in time and I will focus on whether agents’ attempts to learn the prevailing norm lead to a shift in norms.⁸

⁷The shape of the figure when τ is near zero is sensitive to the distributional assumptions. With the uniform specification the maximum possible return to t_q is bounded and t_q^* is bounded away from one as τ approaches zero. If q had been specified as exponentially distributed with parameter t_q , the effect of t_q on the $1 - \tau^{\text{th}}$ percentile of the q distribution would grow without bound as τ approaches zero and the time spent on revisions would decrease all the way to zero in the limit.

⁸This focus is not intended to suggest that whether a community will reach a common norm and the effects of belief or preference heterogeneity on the evolution of social norms are not interesting. Instead, as in Ellison and Fudenberg (2000), the common beliefs learning model is motivated solely by the desire for a tractable model that highlights an important effect.

The model involves a discrete set of time periods $t = 0, 1, 2, \dots$. At the start of period t all economists believe that the social norm is (α_t, z_t) . They then write a paper and try to publish it as in the static game of Section 2 and serve as a referee. The data they receive via referee reports and editorial decisions will suggest to them that the social norm is in fact, $(\hat{\alpha}_t, \hat{z}_t)$. This leads them to alter their beliefs according to

$$\begin{pmatrix} \alpha_{t+1} - \alpha_t \\ z_{t+1} - z_t \end{pmatrix} = k \begin{pmatrix} \hat{\alpha}_t - \alpha_t \\ \hat{z}_t - z_t \end{pmatrix}$$

for some constant $k > 0$. To complete the specification I must describe what data economists gather and how they draw the inferences $(\hat{\alpha}_t, \hat{z}_t)$ from the data.

What data do economists get? I assume that economists get two types of data points. First, when an author submits a paper of quality at least \underline{q} I assume that the referee reports he or she receives give him or her a data point of the form $(q, r(q))$.⁹ These datapoints should all lie on the line $\alpha_t q + (1 - \alpha_t)r(q) = z_t$. I will allow, however, for the possibility that economists are subject to an overconfidence bias when judging the quality of their own work. In particular, I'll assume that they overestimate the r -quality of their initial submission and this leads them to believe that they have been required to achieve an r -quality that is ϵ higher than what they have actually been required to achieve.¹⁰ In this case, the $(q, r(q))$ datapoints actually lie on the line $\alpha_t q + (1 - \alpha_t)r(q) = z_t + (1 - \alpha_t)\epsilon$.

Second, whenever an economist referees a paper that is of sufficiently high quality to be resubmitted he or she gets a data point of the form $(q, r, \text{Accept/Reject})$.^{11,12} Economists

⁹Note that in a slight departure from the static model I've assumed that journals do not provide the author with a list of revisions sufficient to make the paper publishable if the paper's q -quality is so low as to make it inconceivable that a revision will be publishable. I believe that this is a good description of journal practices. I did not try to incorporate such behavior by referees in the static model, however, because it seemed a needless complication and because it creates a possibility for another type of equilibrium multiplicity that I did not feel was important: authors won't save time for revisions if referees won't ask for large revisions because they don't think they're feasible.

¹⁰Given that the acceptance frontier is downward sloping in q - r space this assumption is almost equivalent to assuming that authors believe their papers to be of slightly higher q -quality than they actually are, or to assuming that have biased views of both the q - and r -quality of their work. I've chosen the formulation above because it makes some results a little cleaner (especially those about small α behavior.)

¹¹Another important data source for real world economists is reading journals. Given the word-of-mouth assumption below, this would just provide redundant observations on all of the acceptances. For this reason, nothing would be changed if I included this data source in the model.

¹²An ambiguity in the model is what happens if the assumed standards is so excessively high that fewer than τ papers are resubmitted. In the simulations in the next section I assume that in this case editors accept some papers that are not resubmitted and that these acceptances are observed by the referees.

expect to see all papers lying above the line $\alpha_t q + (1 - \alpha_t)r = z_t$ being accepted and all papers lying below this line being rejected.

If economists each saw a finite number of data points, then their analyses would lead to a divergence in the second period beliefs even if they entered the model with common beliefs. To keep the model tractable I avoid this by invoking word-of-mouth communication. I assume that each economist talks to all of the other economists in each period (despite there being uncountably many) and thereby sees all of the data points that were generated in that period. While this makes each authors own experiences a measure zero subset of his or her dataset, I do not want to lose the possibility of inferences being affected by the authors' misperceptions of the quality of their own work. I thus assume that the $(q, r(q))$ observations economists receive by hearing others talk about the referee reports they received are contaminated by the author's bias (and that the listeners do not realize this).

What do economists do with the data they obtain each period? Fitting the (α, z) model involves estimating the slope and intercept of a line to simultaneously fit the $(q, r(q))$ data and divide the acceptance and rejection regions. Typically, no line will do both jobs perfectly. I assume that this does not cause economists to lose faith in their model of the world and that they go ahead and try to fit the data as well as possible with the (α, z) model.¹³

Formally, I assume that economists' period t analyses take the form

$$(\hat{\alpha}_t, \hat{z}_t) = \arg \min_{\alpha, z} L(\alpha, z; \mu_1, \mu_2),$$

where $L(\alpha, z)$ is a loss function that describes how poorly the the data (a measure μ_1 describing the $(q, r(q))$ points and a measure μ_2 describing the $(q, r, Accept/Reject)$ points) fit the hypothesis that all referees and the journal editor are applying the (α, z) social norm. Specifically, I assume that

$$L(\alpha, z; \mu_1, \mu_2) = L_1(\alpha, z; \mu_1) + L_2(\alpha, z; \mu_2),$$

¹³Formally, economists are estimating a misspecified model. A justification for not worrying about economists noticing the misspecification is that in a more realistic model economists would only receive a finite number of datapoints and there would be a random component to each observation, so the form of the misspecification would not be so apparent. The idea that economists struggle to reconcile hard-to-reconcile observations while maintaining biased self images does not seem unrealistic to me.

where

$$L_1(\alpha, z; \mu_1) = \int \left(r(q) - \frac{z - \alpha q}{1 - \alpha} \right)^2 d\mu_1(q),$$

is a standard mean squared deviation measure of the distance (in the r -dimension) between the $(q, r(q))$ data points and the line $\alpha q + (1 - \alpha)r = z$ and

$$L_2(\alpha, z; \mu_2) = \int_{R_{UA}} \left(\frac{z - \alpha q}{1 - \alpha} - r \right) d\mu_2(q, r) + \int_{R_{UR}} \left(r - \frac{z - \alpha q}{1 - \alpha} \right) d\mu_2(q, r),$$

where R_{UA} is the set of (q, r) values for which papers were “unexpectedly accepted” despite failing to meet the (α, z) standard and R_{UR} is the set of “unexpectedly rejected” papers that met the (α, z) standard but were rejected. L_2 can be thought of as the product of the fraction of accept/reject decisions that are inconsistent with the (α, z) model and the average degree of error (in the r -dimension) that appears to be embodied in the “unexpected” decisions.

Obviously other loss functions would be reasonable. The most natural would probably be the negative of the log likelihood of the data under a hypothesis involving referees and the editor trying to apply the (α, z) norm but making idiosyncratic errors in judging the quality of each paper. Analyzing such a specification would require examining integrals of CDF’s and PDF’s, however, and I felt that the specification above was the best compromise in terms of reflecting a similar goodness-of-fit notion and being tractable.

6 Analysis of the dynamic model with no overconfidence bias ($\epsilon = 0$)

In this section I discuss the behavior of the dynamic model when economists do not have an inflated view of the quality of their own work. The main observations are that consistent social norms are steady states of the model and that when referees are too demanding economists infer both that their standards were too high and that q -quality must be relatively less important than they had thought.

6.1 Steady states

When there is no overconfidence bias it is easy to see that any consistent social norm of the static model is a steady state of the dynamic learning model.

Proposition 5 *Suppose $\epsilon = 0$ in the dynamic model and (α_0, z_0) is a consistent social norm. Then, $(\alpha_t, z_t) = (\alpha_0, z_0)$ for all t .*

Proof

All points $(q, r(q))$ in the data obtained from referees' reports lie exactly on the line $\alpha_0 q + (1 - \alpha_0)r(q) = z_0$. The editor's decisions are also consistent with imposing the (α_0, z_0) standard, i.e. all rejected papers have $\alpha_0 q + (1 - \alpha_0)r - z_0 \leq 0$ and all accepted papers have $\alpha_0 q + (1 - \alpha_0)r - z_0 \geq 0$. Hence, both L_1 and L_2 are zero for $(\alpha, z) = (\alpha_0, z_0)$. Because the q -distribution is nonatomic on a continuous support, L_1 is strictly positive (and L_2 is always nonnegative) for any other (α, z) . The unique minimum of the loss function is thus $(\hat{\alpha}_0, \hat{z}_0) = (\alpha_0, z_0)$.

QED.

6.2 Disequilibrium dynamics

In this section I discuss the disequilibrium behavior of the dynamic model. The results in this section (and in the remainder of the paper) will concern the uniform technology for q -production, $q \sim U[0, t_q]$. The whole of what I want to say in this section can be summarized concisely by saying that the dynamic evolution of economists' beliefs about the social norm (α, z) outside of equilibrium follows the pattern illustrated in Figure 5. The figure was constructed by solving the model numerically for various initial beliefs under the assumption that $q \sim U[0, t_q]$, $\tau = 0.3$, $\sigma = 0.2$ and $h(t) = \sqrt{t} - t/2$. The solid line in the figure is the locus of consistent social norms $(\alpha, z^*(\alpha))$. The vectors in the figure are proportional to the change in beliefs $(\alpha_{t+1} - \alpha_t, z_{t+1} - z_t)$ that occurs for various initial beliefs.¹⁴ To help organize the dynamics I have also placed a vertical dashed line in the figure at $\alpha = 0.3363$. This is where the equilibrium shifts from the somewhat low α form to the typical form.

The locus of consistent social norms and the dashed line divide (α, z) space into four regions. In three of the four regions the learning process is mostly just a straightforward

¹⁴The speed with which beliefs change in the model is determined by an arbitrary scaling parameter k . The figure uses $k = 0.6$. Note that unlike all other graphs in this paper the x and y axes in this figure do not have the same scale. The y -axis has been magnified by a factor of 1.5. These choices reflect an attempt to maximize the visibility of the directions and minimize clutter.

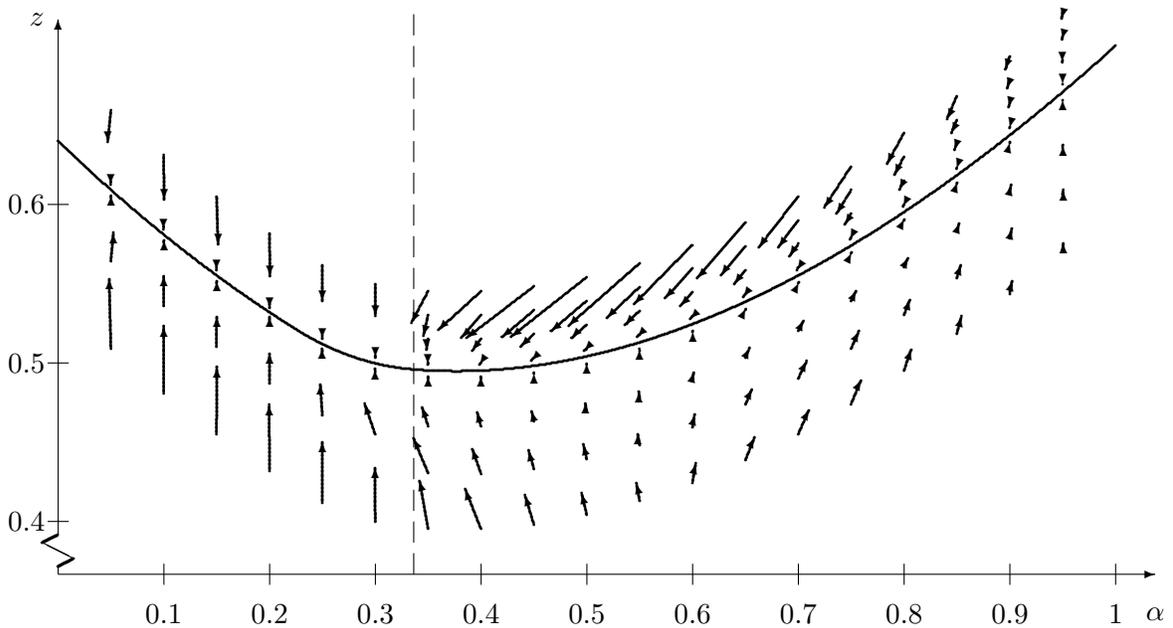


Figure 5: The disequilibrium evolution of social norms when $\epsilon = 0$.

adjustment of the overall quality threshold: when referees try to impose a standard that would not allow the editor to fill the journal they infer from the unexpected acceptances that they must reduce z ; when referees are too soft and the editor has to turn down some papers they recommend they learn to choose a higher z .¹⁵

What is most important to my main argument is what happens in the fourth region — the upper right part of Figure 5. Suppose that the (α_t, z_t) standard is unreasonably high, i.e. $z > z^*(\alpha)$. Suppose also that the distribution of resubmitted papers has the “typical” form. Economists will then (correctly) perceive that referees are asking them to meet a very high standard and that some papers that they thought were submarginal are being accepted. The conflict in this data leads economists to do two things: to believe that quality standards are less demanding than they had thought; *and* to believe that r -quality is relatively more important than than they had thought.

To illustrate why economists make this inference, Figure 6 contains an enlarged view of the data economists get in one such case.¹⁶ The bold line represents the $(q, r(q))$ dat-

¹⁵The dynamics in the $z < z^*(\alpha)$ and α large region fit this description only if α is not too large. I discuss what happens in the “high α ” case at the end of this section.

¹⁶The figure graphs the quality distribution and the best fit $(\hat{\alpha}, \hat{z})$ when initial beliefs are that $\alpha = 0.5$

apoints they get from referee reports. The outlined area is the support of the (uniform) quality distribution. All papers above and to the right of the bold line are accepted. The journal editor also accepts papers in the shaded region (to the surprise of the referees). Lower quality papers are rejected. The lines below the q -axis and to the left of the r -axis illustrate the support of the q and r distributions among resubmitted papers. I have used bold lines to show the support of the quality distribution for the unexpectedly accepted papers. These papers are at the low end of the q distribution and at the high end of the r distribution. Economists' rationalize these acceptances in part by concluding that r must be more important than they had thought. In the figure, the dashed line graphs the social norm $(\hat{\alpha}, \hat{z})$ that best fits the data (given the assumed loss function). The flatter line accounts for many of the unexpected acceptances and gives a good fit to the high q part of the $(q, r(q))$ data.

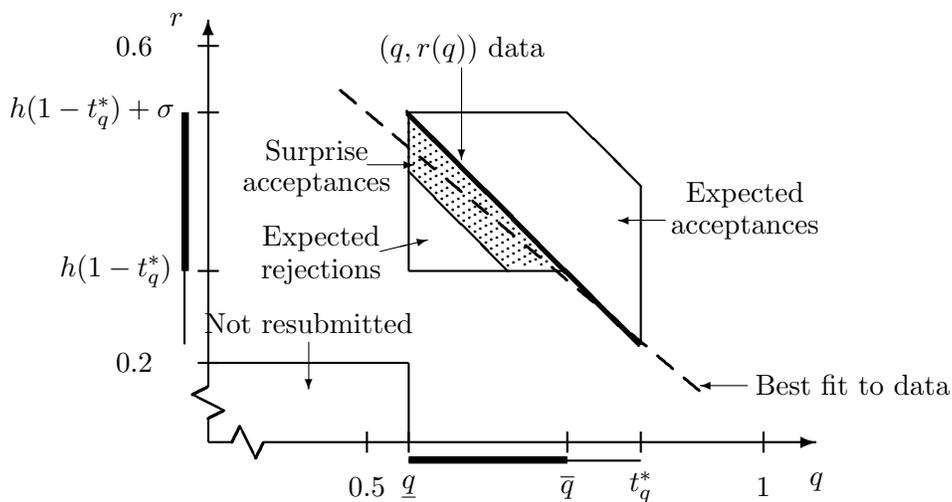


Figure 6: Economists' inferences when standards are too high: the “typical” case

Figure 7 contains a similar diagram illustrating economists inferences when referees' beliefs (α_t, z_t) are unreasonably tough and α_t is sufficiently low so that the distribution of resubmitted papers has the “low α ” form — all papers are resubmitted and all authors devote the same maximum effort to their revisions. Here, the “unexpectedly accepted” papers are uniformly distributed in the q dimension, and the dotted line illustrates that the and $z = 0.53417$ with $q \sim U[0, t_q]$, $h(t) = \sqrt{t} - t/2$, $\sigma = 0.2$ and $\tau = 0.3$.

best fit is obtained by slightly lowering z while leaving the slope of the line unchanged.

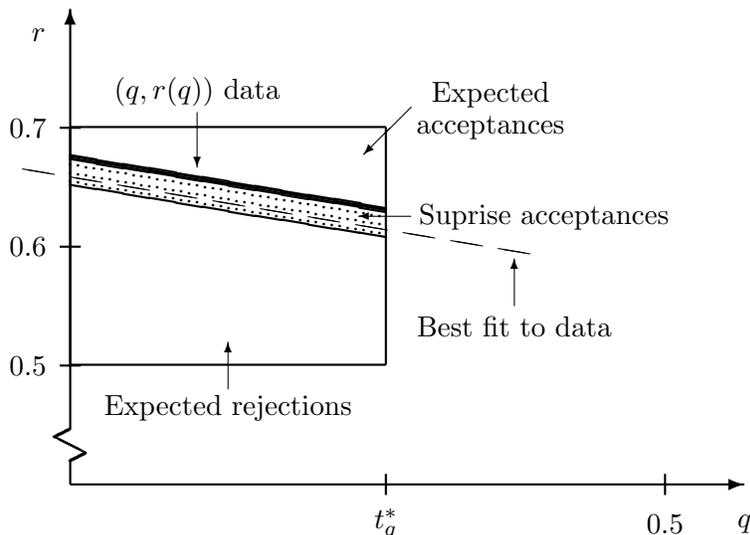


Figure 7: Inferences when standards are too high: the “low α ” case.

Even with the simple loss function I’ve chosen, getting analytic expressions for the optimal inference given an inconsistent (α_t, z_t) is difficult. Proposition 6 is a characterization of the dynamics that brings out the main observations I’ve mentioned above. The proposition characterizes the dynamics for initial beliefs that are close to being consistent, i.e. for z_t close to $z^*(\alpha_t)$. Parts (a) and (b) note that in the low α and somewhat low α cases economists do not adjust their estimate of α (at least approximately) and adjust their estimate of z toward $z^*(\alpha_t)$. Part (c) notes that when referees’ beliefs correspond to a standard that is too low the dynamics are similar in the “typical” case: the dynamics are approximately vertical when the social norm is approximately consistent. Part (d) relates to my main observation. It notes that when z_t is slightly larger than $z^*(\alpha_t)$ the dynamics involve both a reduction in α and a reduction in the overall quality standard (after accounting for the change that is induced mechanically by the change in α). The shifts in the two parameters are comparable in magnitude. The proof of the proposition is contained in Appendix A.

Proposition 6 Consider the dynamic model described above with $F(q|t_q) \sim U[0, t_q]$. Let $t_q(\alpha, z)$ be economists’ optimal time allocation when they believe that the social norm is

(α, z) . Write $b(z) \approx a(z - z^*(\alpha))$ as shorthand for $\lim_{z \rightarrow z^*(\alpha)} \frac{b(z)}{z - z^*(\alpha)} = a$.

(a) Suppose that for a given $\alpha_t \in (0, 1)$ the unique equilibrium for the social norm $(\alpha_t, z^*(\alpha_t))$ has the low α form. Then there exists a constant $a > 0$ such that for z_t in a neighborhood of $z^*(\alpha_t)$ the dynamics have

$$\begin{aligned}\alpha_{t+1} - \alpha_t &= 0 \\ z_{t+1} - z_t &= a(z^*(\alpha_t) - z_t)\end{aligned}$$

(b) Suppose that for a given $\alpha_t \in (0, 1)$ the unique equilibrium for the social norm $(\alpha_t, z^*(\alpha_t))$ has the somewhat low α form and that $\frac{\partial^2 G}{\partial t^2}$ is strictly positive at $t = t_q(\alpha_t, z^*(\alpha_t))$. Then there exists a constant $a > 0$ such that for z_t close to $z^*(\alpha_t)$ the dynamics have

$$\begin{aligned}\alpha_{t+1} - \alpha_t &\approx 0 \\ z_{t+1} - z_t &\approx a(z^*(\alpha_t) - z_t)\end{aligned}$$

For z_t slightly larger than $z^*(\alpha_t)$ the dynamics have $\alpha_{t+1} - \alpha_t = 0$.

(c) Suppose that for a given $\alpha_t \in (0, 1)$ the unique equilibrium for the social norm $(\alpha_t, z^*(\alpha_t))$ has the “typical” form and $z_t < z^*(\alpha_t)$. Then there exists a constant $a > 0$ such that for z_t close to $z^*(\alpha_t)$ the dynamics have

$$\begin{aligned}\alpha_{t+1} - \alpha_t &\approx 0 \\ z_{t+1} - z_t &\approx a(z^*(\alpha_t) - z_t),\end{aligned}$$

(d) Suppose that for a given $\alpha_t \in (0, 1)$ the unique equilibrium for the social norm $(\alpha_t, z^*(\alpha_t))$ has the “typical” form and $z_t > z^*(\alpha_t)$. Let $M_q = (\underline{q}(\alpha_t, z_t) + t_q(\alpha_t, z_t))/2$ and $M_r = \frac{z_t - \alpha_t M_q}{1 - \alpha_t}$. Then there exist constants $a_1 > 0$ and $a_2 > 0$ such that for z_t close to $z^*(\alpha_t)$ the dynamics have

$$\begin{aligned}\alpha_{t+1} - \alpha_t &\approx -a_1(z_t - z^*(\alpha_t)) \\ z_{t+1} - z_t &\approx a_2(z^*(\alpha_t) - z_t) + (\alpha_{t+1} - \alpha_t)(M_q - M_r)\end{aligned}$$

The one notable feature of the Figure 5 that I have left out of the discussion so far is what happens when $z < z^*(\alpha)$ and α is sufficiently high so that the equilibrium has the high α form. It is apparent from the figure that in this case economists conclude that

q is relatively more important than they had thought. The argument is similar to the argument for why economists conclude that r is more important than they had thought when standards are too high in a typical equilibrium. The unexpectedly rejected papers are relatively low q papers and hence a steeper line allows referees to account for many of the unexpected rejections while maintaining a good fit to the $r(q)$ data for high q papers. I have not discussed this case in more detail because in a couple of ways the argument here seems less plausible. First, it involves economists mistakenly not achieving levels of r -quality that they could have achieved. Second, the effect derives from economists trying to fit datapoints with $r(q)$ negative.

7 The overconfidence bias and gradual evolution

In this section I show that adding a slight overconfidence bias produces a model in which social norms can slowly and steadily evolve over a long period to place ever more emphasis on r -quality.

7.1 ϵ -perturbations of dynamics with a continuum of steady-states

Before discussing the model, it is instructive to discuss its structure in more generality. The dynamic model is of the form

$$\begin{pmatrix} \alpha_{t+1} - \alpha_t \\ z_{t+1} - z_t \end{pmatrix} = k \begin{pmatrix} \hat{\alpha}_t - \alpha_t \\ \hat{z}_t - z_t \end{pmatrix}$$

where $(\hat{\alpha}, \hat{z}) = \arg \min_{\alpha, z} L(\alpha, z; \alpha_t, z_t)$.¹⁷ A social norm (α_t, z_t) is a steady-state only if it is a solution to

$$\begin{aligned} \frac{\partial L}{\partial \alpha}(\alpha_t, z_t; \alpha_t, z_t) &= 0 \\ \frac{\partial L}{\partial z}(\alpha_t, z_t; \alpha_t, z_t) &= 0 \end{aligned}$$

This is a system of two equations in two unknowns. Ordinarily, one would expect such a system to have one solution (or zero or a few). The fact that the dynamic model of the previous section has a continuum of equilibria indicates that it is somewhat special.

¹⁷While I earlier defined L as depending on the measures μ_1 and μ_2 describing the two types of data, μ_1 and μ_2 are themselves functions of α_t and z_t . I use α_t and z_t as arguments of L in this section to clarify the nature of the dynamic.

What happens if we take a dynamic model with a continuum of equilibria and perturb it slightly? The answer of course depends on how the system is perturbed. To take a simple example, consider a dynamic of the form above with the loss function

$$L(\alpha, z; \alpha_t, z_t) = (\alpha - \alpha_t)^2 + (z - z_t)^2 + (z - \alpha)^2.$$

This model has every point on the line $z_t = \alpha_t$ as a steady state. One thing that can happen with an ϵ -perturbation is an ϵ -order shift in the set of steady states. For example, if we perturb the loss function above to

$$L(\alpha, z; \alpha_t, z_t, \epsilon) = (\alpha - \alpha_t)^2 + (z - z_t)^2 + (z - (\alpha + \epsilon))^2,$$

the system has a continuum of steady states given by $z_t = \alpha_t + \epsilon$.

With a generic perturbation, however, the continuum of steady states will disappear. For example, if we instead perturb the system to

$$L(\alpha, z; \alpha_t, z_t, \epsilon) = (\alpha - \alpha_t)^2 + (z - z_t)^2 + (z - \alpha)^2 + \epsilon z^2,$$

the only remaining steady-state is $\alpha_t = z_t = 0$. What happens to the former equilibria? In this example, the ϵ perturbed dynamics have

$$\begin{aligned} \hat{\alpha} - \alpha_t &= \frac{1 + \epsilon}{3 + 2\epsilon}(\alpha_t - z_t) - \frac{\epsilon}{3 + 2\epsilon}(\alpha_t + z_t) \\ \hat{z} - z_t &= \frac{1 + \epsilon}{3 + 2\epsilon}(z_t - \alpha_t) - \frac{\epsilon}{3 + 2\epsilon}(\alpha_t + z_t) \end{aligned}$$

The first terms on the right hand sides of these equations tell us that from any initial condition the dynamics lead quickly to a neighborhood of the nearly stable locus $z_t = \alpha_t$. The system then evolves at an ϵ rate in a neighborhood of this locus toward the steady state. If the initial condition is very from the steady state a long gradual evolution would be observed.

Obviously, the most natural way to account for a long gradual trend in an economic variable will usually be to view the trend as reflecting a continuous shift in the equilibrium of a model due to a trending exogenous variable. The most general idea the dynamic model is intended to convey is that the disequilibrium dynamics in perturbations of models with a continuum of equilibria may provide an alternate method for explaining some such trends.

7.2 Social norms for academic publishing

My main observation about the model with no overconfidence bias was that *if* referees try to hold authors to an unreasonably high standard, then social norms will evolve to place more weight on r -quality. This disequilibrium shift is not an appealing candidate for explaining observed shifts in academic standards for two reasons. First, such an explanation would be incomplete in that we have no reason to expect initial beliefs to be too demanding as opposed to too undemanding. Second, and more importantly, the model does not fit a long gradual trend. Instead, social norms in such a model move very quickly to a neighborhood of the equilibrium set and then converge slowly without much further movement along the equilibrium set.

The dynamics with an ϵ overconfidence bias are qualitatively different. When beliefs are far from the equilibrium set, the ϵ -perturbation has little impact — we again see rapid convergence to a neighborhood of the set of equilibria of the unperturbed model. The overconfidence then becomes important. In the typical case it destabilizes the former equilibria. If economists' initial beliefs correspond to a consistent social norm, then their misperceptions of the referee reports they receive will lead them to conclude that overall quality standards must be higher than they had thought (i.e. $\hat{z} - z_t > 0$.) For this reason, referees will perpetually try to hold authors to a standard that is slightly higher than is feasible. The ϵ -overconfidence does not affect the argument that economists will conclude that r -quality is more important than they had thought whenever standards are higher than is feasible. Hence, when the equilibrium has the typical form we will observe a gradual evolution of social norms through the near equilibrium set toward lower α values.

Must we look forward to a world with no q -quality whatsoever? In my model at least, the answer is no. In the neighborhood of a consistent social norm the effect of a small overconfidence bias is to make economists think that z must be slightly higher than they had thought. In the low α and somewhat low α cases, when the standard is slightly too high economists infer that z must be slightly lower than they had thought. For any such α , the two effects turn out to exactly offset for some z slightly greater than $z^*(\alpha)$. The ϵ -perturbed model has a continuum of steady-states lying just above the low α and somewhat low α

portions of the set of steady states of the unperturbed model. The model thus predicts that the evolution of social norms will come to a halt as soon as r is sufficiently important so that no paper's idea is good enough to let its author be sure that he or she will eventually be able to get an acceptance.

Figure 8 illustrates the dynamics of the system with a small overconfidence bias. The figure was generated by solving the model numerically for various initial beliefs under the assumption that $q \sim U[0, t_q]$, $\tau = 0.3$, $\sigma = 0.2$, $h(t) = \sqrt{t} - t/2$ and $\epsilon = 0.01$. The solid curve on the left side of the figure is the locus of steady states $(\alpha, z^\epsilon(\alpha))$. The curves with the large dots on the right side of the figure graph the evolution of social norms over time from several initial conditions. They illustrate that from initial conditions with α large the system initially evolves mostly toward the set of nearly stable norms and then moves along this set until the somewhat low α region is reached. The large dots mark the beliefs that prevail at the end of each period.¹⁸ The fact that the dots are initially far apart on each curve and then become regularly and closely spaced reflects that the initial movement toward the nearly stable set is rapid and that the subsequent evolution toward lower values of α is slow and steady.

Proposition 7 provides a formal description of some properties of the system. Part (a) notes that the model has a continuum of equilibria covering roughly the low α and somewhat low α ranges. Part (b) notes that when α is such that the equilibrium has the typical form there is no steady state: at $(\alpha, z^*(\alpha))$ the data is better fit by increasing z ; when z is slightly higher than $z^*(\alpha)$ the fit is improved by reducing α .

Proposition 7 *Consider the dynamic model described above with $F(q|t_q) \sim U[0, t_q]$. Let $t_q(\alpha, z)$ be economists' optimal time allocation when they believe that the social norm is (α, z) .*

(a) Suppose that for a given $\alpha \in (0, 1)$ the unique equilibrium for the social norm $(\alpha, z^(\alpha))$ with $\epsilon = 0$ has the low α or somewhat low α form. Suppose that $\frac{\partial^2 G}{\partial t^2}$ is strictly positive at $t = t_q(\alpha, z^*(\alpha))$. Then for ϵ sufficiently small there exists a value of z , $z^\epsilon(\alpha)$ such that $(\alpha, z^\epsilon(\alpha))$ is a steady state of the model with ϵ -overconfidence*

¹⁸Again I've assumed in constructing the figure that $k = 0.6$.

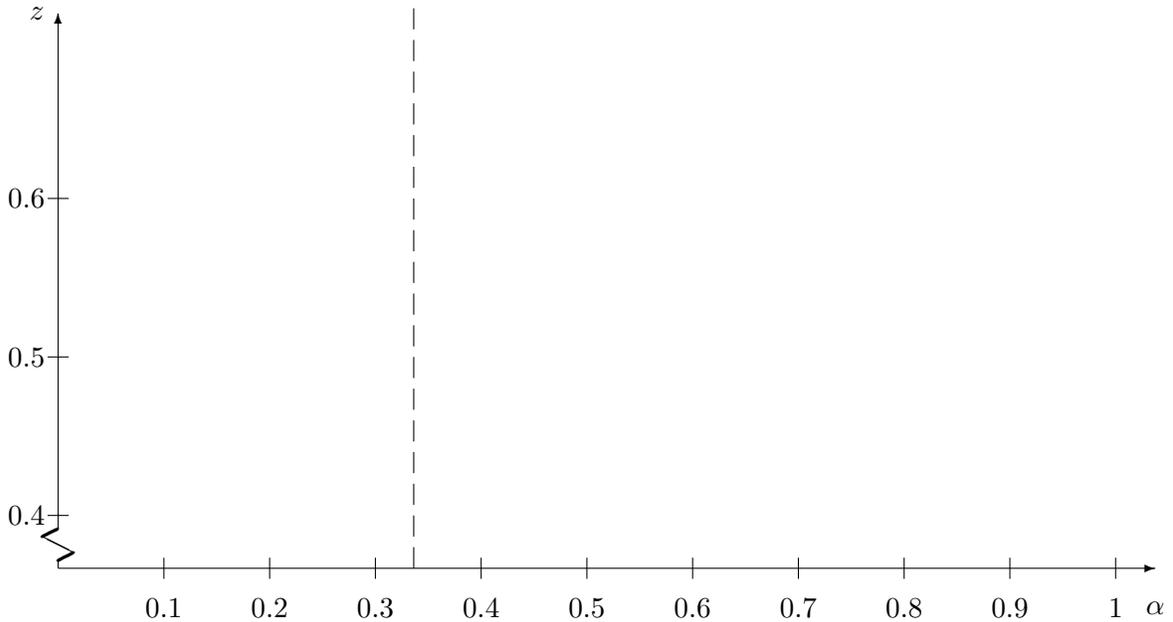


Figure 8: The disequilibrium evolution of social norms when $\epsilon > 0$.

Further, there exists a positive constant a such that, $z^\epsilon(\alpha) - z^*(\alpha) \approx a\epsilon$ when ϵ is small. In the low α case $z^\epsilon(\alpha)$ is exactly equal to $z^*(\alpha) + 2(1 - \alpha)\sigma\epsilon$ when ϵ is sufficiently small.

(b) Suppose that for a given $\alpha \in (0, 1)$ the unique equilibrium for the social norm $(\alpha, z^*(\alpha))$ with $\epsilon = 0$ has the typical form. When $\epsilon > 0$ we have $\frac{\partial L}{\partial z}(\alpha, z^*(\alpha); \alpha, z^*(\alpha)) < 0$. For ϵ sufficiently small there exists a $z > z^*(\alpha)$ for which the distribution of paper qualities and expectedly and unexpectedly accepted papers has the typical form pictured in Figure 6 and the loss function has $\frac{\partial L}{\partial z}(\alpha, z; \alpha, z) = 0$. For any such z , $\frac{\partial L}{\partial \alpha}(\alpha, z; \alpha, z) < 0$. Hence, the system does not have a steady state where the distribution of paper qualities has the typical form.

Let $z^\epsilon(\alpha)$ be the smallest value of z such that $\frac{\partial L}{\partial z}(\alpha, z; \alpha, z) = 0$. Then there exist positive constants a and b such that $z^\epsilon(\alpha) - z^*(\alpha) \approx a\epsilon$ and $\frac{\partial L}{\partial \alpha}(\alpha, z^\epsilon(\alpha); \alpha, z^\epsilon(\alpha)) \approx -b\epsilon$ for small ϵ .

For those who do not believe that academics suffer from overconfidence bias (and those who are wondering if observed changes in standards should be taken as providing evidence of such a bias), I would like to note that a gradual evolution toward lower α norms can

be generated by many small modifications to the basic dynamic model. Essentially, any perturbation that makes referees perpetually try to hold authors to a slightly infeasibly high standard will do the same thing. One example would be an assumption that referees try to make up more extensive lists of revisions than is standard to impress editors with their thoroughness. Another would be an assumption that are competitive (or spiteful) and try to hold back others in their field by imposing standards that are slightly higher than the norm (perhaps because making requests that are even more demanding would expose their spite).

In a standard one-dimensional model where the optimal level of revisions is determined by a cost of revisions or in a one-dimensional learning model where referees are learn z by observing referees' reports and editors' decisions, ϵ perturbations like these just produce a model in which the original equilibrium (or steady-state) is shifted by ϵ . In the two-dimensional learning model, however, ϵ changes can greatly change the equilibrium set and create steady long-term disequilibrium evolution.

8 Conclusion

I have proposed that it is helpful to think about observed changes in the economics publishing process with a two-dimensional q - r model of quality. The idea behind the dynamic model is that social norms for weighing different aspects of quality may shift as economists struggle to reconcile the high standards being applied to them with the mediocrity they see in journals. The model predicts a long gradual shift in standards. Academics react by spending less and less time developing new insights and more and more time polishing papers.

Among the many possible extensions to the model, I view the incorporation of randomness in the assessment of quality and in economists' data samples as the most intriguing. Referees who receive signals suggesting that standards are higher than they are may conclude that r -quality is more important than they thought, while referees who receive signals suggesting that standards are lower than they are will not draw the opposite conclusion. Even without an overconfidence bias we may see increasing emphasis placed on r -quality. Sobel's (1998) work suggests that randomness in assessments due to heterogeneity in tastes

may have more subtle effects.

What are the welfare effects of changes in publication standards? There are no answers within my model, because individual preferences over q and r do not appear. If preferences are time invariant, then welfare changes as standards evolve. Whether changes are welfare increasing or welfare decreasing depends on how the prevailing social norm differs from the optimum given authors' and readers' preferences.

The changes of the last few decades have had a substantial impact on economists. Many young economists report spending as much time revising old papers as working on new ones. Guiding larger and more frequent revisions is an additional burden on referees and editors. If the changes that have occurred were accidental and many other social norms are really possible, then a discussion in the profession of what standards we would like to have would be valuable.

While I have emphasized the model of learning with overconfidence, other explanations for the observed changes are possible. Indeed, one of the main motivations for the static model is to clarify how the growth of the economics profession, changes in the set of ideas waiting to be discovered and other factors might alter the publication process. Ultimately, which of the potential explanations are most important is an empirical question. I attempt to begin this sorting out in Ellison (2000).

How else might one examine the evolutionary model empirically? With ideal data one could directly examine referees' demands and see how they are affected by referees' experiences as authors. A general premise of the model that may be more easily examined is that learning occurs within communities of referees. A good empirical test would be to observe whether a random shock to a particular field at a particular journal, e.g. the appointment of a new editor who likes revisions, affects how papers in the field are treated at other journals. Another feature that distinguishes the evolutionary model from equilibrium models is that transitory shocks have permanent effects. For example, even after a revision-loving editor is replaced, the fact that referees learned a high revision norm will ensure that publication remains slow for years to come.

In addition to trying to change how people think about academic publishing, I have tried to make the general point that even long run trends can be disequilibrium outcomes.

Comparative statics of equilibria will remain the standard for explaining trends, but I hope that models like that I've developed here will find other applications.

Appendix A

Proof of Proposition 6

(a) In the low α case for (z, t_q) in a neighborhood of $(z^*(\alpha_t), t_q(\alpha_t, z^*(\alpha_t)))$ we have

$$G(z, t_q) = \frac{1}{\sigma} \left(\frac{z - \alpha_t t_q / 2}{1 - \alpha_t} - h(1 - t_q) \right).$$

This function has $\frac{\partial G}{\partial t_q} = -\frac{\alpha_t}{2\sigma(1-\alpha_t)} + h'(1 - t_q)$, which is independent of z . It also has $\frac{\partial^2 G}{\partial t_q^2} = -h''(1 - t_q) > 0$, and hence in a neighborhood of $z^*(\alpha_t)$, $t_q(\alpha_t, z_t)$ is independent of z_t . The continuity of the thresholds implies that the ordering $\underline{q} < 0 < m(t_q) < \bar{q}$ holds for all z_t in a neighborhood of $z^*(\alpha_t)$.

Write $r_a(q; \alpha_t, z_t)$ for the level of r -quality that is actually necessary for an editor to accept a paper of q -quality q when the population believes the standard is (α_t, z_t) . Because $t_q(\alpha_t, z_t)$ is locally independent of z_t and all authors revise to the greatest extent possible, $r_a(q; \alpha_t, z_t) = r(q; \alpha_t, z^*(\alpha_t))$ for z_t near $z^*(\alpha_t)$. The situation is thus like that pictured in Figure 7. When $z_t < z^*(\alpha_t)$ the situation is similar, but involving a parallelogram of unexpectedly rejected papers lying just above the $(q, r(q))$ line.

To describe economists' inferences, I'll make a change of variables and analyze the minimization of the loss function over m and w where $m = \frac{-\alpha}{1-\alpha}$ is the slope of the line and $w = \frac{z-\alpha M_q}{1-\alpha}$ is the level of r quality required of a paper with the mean q -quality, $M_q \equiv (t_q(\alpha_t, z_t) + \max(0, \underline{q}(\alpha_t, z_t)))/2$. I'll carry out the calculations for $z_t > z^*(\alpha_t)$. The calculations in the opposite case are identical but with some signs reversed.

With the change of variables L_1 takes on a very simple form.¹⁹

$$\begin{aligned} L_1(m, w) &= \int_0^{t_q(\alpha_t, z_t)} (m(q - M_q) + w - r(q; \alpha_t, z_t))^2 \frac{1}{t_q(\alpha_t, z_t)} dq \\ &= \frac{1}{t_q(\alpha_t, z_t)} \int_0^{t_q(\alpha_t, z_t)} (m(q - M_q) + w - (m_t(q - M_q) + w_t))^2 dq \\ &= \frac{1}{t_q(\alpha_t, z_t)} \left[(m - m_t)^2 \frac{(q - M_q)^3}{3} + (m - m_t)(w - w_t)(q - M_q)^2 + (w - w_t)^2 q \right]_0^{t_q(\alpha_t, z_t)} \\ &= \frac{1}{12} t_q(\alpha_t, z_t)^2 (m - m_t)^2 + (w - w_t)^2 \end{aligned}$$

By making a few comparisons it is easy to see that the minimum of $L_1 + L_2$ can not be achieved for $w > w_t$, or for $w < r_a(M_q, \alpha_t, z_t)$, or with a slope m for which $w + m(-M_q)$ is outside the interval $[r_a(0; \alpha_t, z_t), r(0; \alpha_t, z_t)]$. (For example, to show the second note that for any such w , $L(m, w) > L(m_t, r_a(M_q, \alpha_t, z_t))$ because L_1 is smaller at $(m_t, r_a(M_q, \alpha_t, z_t))$ and L_2 has its global minimum there.) In the range containing any potential minimum, L_2 turns out to also be a simple quadratic.

$$L_2(m, w) = \int_0^{t_q(\alpha_t, z_t)} \int_0^{w - r_a(M_q; \alpha_t, z_t) + (m - m_t)(q - M_q)} r \frac{1}{\sigma} dr \frac{1}{t_q(\alpha_t, z_t)} dq$$

¹⁹To make the formulas more readable I'll often omit the μ_1 and μ_2 arguments of L_1 and L_2 . μ_1 and μ_2 are determined by α_t and z_t , so I'll also sometimes substitute α_t and z_t (or m_t and w_t) as arguments. I will also omit arguments of M_q , t_q , \bar{q} , and \underline{q} to improve readability.

$$\begin{aligned}
&= \frac{1}{2\sigma t_q(\alpha_t, z_t)} \int_0^{t_q(\alpha_t, z_t)} (w - r_a(M_q; \alpha_t, z_t) + (m - m_t)(q - M_q))^2 dq \\
&= \frac{1}{24\sigma} t_q(\alpha_t, z_t)^2 (m - m_t)^2 + \frac{1}{2\sigma} (w - r_a(M_q; \alpha_t, z_t))^2.
\end{aligned}$$

Hence,

$$L(m, w; m_t, w_t) = \frac{1}{6} t_q(\alpha_t, z_t)^2 (m - m_t)^2 + (w - w_t)^2 + \frac{1}{2\sigma} (w - r_a(M_q; \alpha_t, z_t))^2.$$

The minimum clearly involves $\hat{m} = m_t$. This gives the first part of the conclusion: $\hat{\alpha} = \alpha_t$.

The minimizing value for w is $\hat{w} = \frac{2w_t + (1/\sigma)r_a(M_q; \alpha_t, z_t)}{2 + 1/\sigma}$. Recall that r_a is independent of z_t in a neighborhood of $z^*(\alpha_t)$. We thus have

$$\begin{aligned}
r_a(M_q; \alpha_t, z_t) &= \frac{z^*(\alpha_t) - \alpha_t M_q}{1 - \alpha_t} \\
&= \frac{z^*(\alpha_t) - z_t}{1 - \alpha_t} + \frac{z_t - \alpha_t M_q}{1 - \alpha_t} = \frac{z^*(\alpha_t) - z_t}{1 - \alpha_t} + w_t.
\end{aligned}$$

Substituting this into the expression for \hat{w} gives

$$\hat{w} - w_t = \frac{1}{(2\sigma + 1)(1 - \alpha_t)} (z^*(\alpha_t) - z_t).$$

Using the identities $\alpha_t = \hat{\alpha}$ and $z_t = \alpha_t M_q + (1 - \alpha_t)w_t$ allows us to conclude as desired that

$$\begin{aligned}
z_{t+1} - z_t &= k(\hat{\alpha}M_q + (1 - \hat{\alpha})\hat{w} - z_t) = k(\alpha_t M_q + (1 - \alpha_t)\hat{w} - \alpha_t M_q + (1 - \alpha_t)w_t) \\
&= k(1 - \alpha_t)(\hat{w} - w_t) = k \frac{1}{2\sigma + 1} (z^*(\alpha_t) - z_t).
\end{aligned}$$

(b) The proof for the somewhat low α case is very similar. One difference is that the form of G is different. This makes it possible that the second derivative of G will not be strictly positive at $t_q(\alpha_t, z^*(\alpha_t))$, in which case $t_q(\alpha_t, z_t)$ might not be differentiable at $z_t = z^*(\alpha_t)$. This would cause many complications. To avoid them, I've just assumed in the proposition that $\frac{\partial^2 G}{\partial t_q^2}(\alpha_t, t_q(\alpha_t, z^*(\alpha_t))) > 0$. This ensures that $t_q(\alpha_t, z)$ is differentiable in z at $z^*(\alpha_t)$.

The analysis of the $z_t > z^*(\alpha_t)$ case then proceeds exactly as above to show that

$$\begin{aligned}
\hat{\alpha} - \alpha_t &= 0 \\
\hat{w} - w_t &= \frac{1}{2\sigma + 1} (r_a(M_q; \alpha_t, z_t) - w_t).
\end{aligned}$$

Write $\tau_a(z_t) = 1 - G(z_t; t_q(\alpha_t, z_t))$ for the fraction of papers achieving the z_t standard given the initial beliefs. By the envelope theorem we know that in a neighborhood of $z^*(\alpha_t)$,

$$\begin{aligned}
\tau_a(z_t) &\approx \tau - \frac{\partial G}{\partial z}(z^*(\alpha_t); t_q(\alpha_t, z^*(\alpha_t)))(z_t - z^*(\alpha_t)) \\
&= \tau - \frac{t_q(\alpha_t, z^*(\alpha_t)) - \underline{q}(\alpha_t, z^*(\alpha_t))}{(1 - \alpha_t)\sigma t_q(\alpha_t, z^*(\alpha_t))} (z_t - z^*(\alpha_t)).
\end{aligned}$$

The mass of extra papers the editor accepts when he lowers the standard from $z^*(\alpha_t)$ to $z^*(\alpha_t) - dz$ is $\frac{t_q - \underline{q}}{t_q(1 - \alpha_t)\sigma} dz$. Hence, in a neighborhood of $z^*(\alpha_t)$ we have

$$\begin{aligned} r_a(M_q; \alpha_t, z_t) - w_t &= \frac{(1 - \alpha_t)\sigma t_q}{(1 - \alpha_t)(t_q - \underline{q})} (\tau_a(z_t) - \tau) \\ &\approx -\frac{1}{(1 - \alpha_t)} (z_t - z^*(\alpha_t)) \end{aligned}$$

This gives

$$z_{t+1} - z_t \approx a(z^*(\alpha_t) - z_t),$$

for $a = \frac{k}{2\sigma+1}$ as desired.

The analysis of the $z_t < z^*(\alpha_t)$ case adds another slight complication — the formula for L_2 is slightly different because there are no papers in the triangle bounded by $(\underline{q}, h(1 - t_q) + \sigma)$, $(\underline{q}, r_a(\underline{q}, \alpha_t, z_t))$, and $(\underline{q} + (1 - \alpha_t)(r_a(\underline{q}, \alpha_t, z_t) - r(\underline{q}, \alpha_t, z_t))/\alpha_t, h(1 - t_q) + \sigma)$ that can be unexpectedly rejected. The loss function thus takes the form

$$\begin{aligned} L(m, w; m_t, w_t) &= \frac{2\sigma + 1}{24\sigma} (t_q - \underline{q})^2 (m - m_t)^2 + (w - w_t)^2 + \frac{1}{2\sigma} (w - r_a(M_q; \alpha_t, z_t))^2 \\ &\quad - \frac{1}{\sigma(t_q - \underline{q})} \int_T I(r > r(q; m, w))(r - r(q; m, w)) dq dr, \end{aligned}$$

where T is the triangle bounded by the three points above and I is the indicator function. To show that $\alpha_{t+1} - \alpha_t \approx 0$ it suffices to show that for any $c > 0$ there exists a δ such that $|\hat{m} - m_t| < c(z^*(\alpha_t) - z_t)$ whenever $z_t \in (z^*(\alpha_t) - \delta, z^*(\alpha_t))$. To see this note that for all z_t in some interval below $z^*(\alpha_t)$ we have for any $m < m_t - c(z^*(\alpha_t) - z_t)$

$$\begin{aligned} \frac{\partial L}{\partial m}(m, w) &= \frac{2\sigma + 1}{12\sigma} (t_q - \underline{q})^2 (m - m_t) - \frac{1}{\sigma(t_q - \underline{q})} \frac{\partial}{\partial m} \int_T I(r > r(q; m, w))(r - r(q; m, w)) dq dr \\ &< -\frac{2\sigma + 1}{12\sigma} (t_q - \underline{q})^2 c(z^*(\alpha_t) - z_t) + \frac{A(T)}{\sigma(t_q - \underline{q})} \sup_{(q,r) \in T} \left| \frac{\partial}{\partial m} I(r > r(q; m, w))(r - r(q; m, w)) \right|, \end{aligned}$$

where $A(T)$ is the area of the triangle T . The area of the triangle is $\frac{1 - \alpha_t}{2\alpha_t} (r_a(\underline{q}, \alpha_t, z_t) - r(\underline{q}, \alpha_t, z_t))^2$. The effect of a dm change in m on $r(q; m, w)$ is $q - M_q$, which is largest when q is farthest from M_q . This gives

$$\frac{\partial L}{\partial m}(m, w) \leq -\frac{2\sigma + 1}{12\sigma} (t_q - \underline{q})^2 c(z^*(\alpha_t) - z_t) + \frac{1 - \alpha_t}{4\alpha_t\sigma} (r_a(\underline{q}, \alpha_t, z_t) - r(\underline{q}, \alpha_t, z_t))^2.$$

The $(r_a(\underline{q}, \alpha_t, z_t) - r(\underline{q}, \alpha_t, z_t))^2$ term is a second order effect in $z^*(\alpha_t) - z_t$. Hence, $\frac{\partial L}{\partial m}(m, w) < 0$ for all $m < m_t - c(z^*(\alpha_t) - z_t)$ when z_t sufficiently close to $z^*(\alpha_t)$. Combining this with a similar calculation of the derivative for $m > m_t + c(z^*(\alpha_t) - z_t)$ allows us to conclude that $\hat{m} \in (m_t - c(z^*(\alpha_t) - z_t), m_t + c(z^*(\alpha_t) - z_t))$ as desired.

A similar calculation shows that the result on $z_{t+1} - z_t$ is also unaffected by the second order change in the loss function.

(c) When the equilibrium has the typical form $G(z; t_q)$ is given by

$$G(z; t_q) = \frac{z - (1 - \alpha_t)(h(1 - t_q) + \sigma/2)}{\alpha_t t_q}.$$

An explicit calculation of the first two derivatives of this function shows that $\frac{\partial^2 G}{\partial t_q^2}(z; t_q) > 0$ in a neighborhood of $(z^*(\alpha_t), t_q(\alpha_t, z^*(\alpha_t)))$. This again implies that $\frac{\partial t_q}{\partial z}(\alpha_t, z^*(\alpha_t))$ exists and that the distribution of paper qualities has the typical form for z_t in some neighborhood of $z^*(\alpha_t)$.

The $(q, r(q))$ line and the set of unexpectedly rejected papers have exactly the same form here as in $z_t < z^*(\alpha_t)$ case of part (b) of the proposition. The result is thus identical to the result for that case.

(d) As above t_q is differentiable in z at $z^*(\alpha_t)$. The distribution of paper qualities and outcomes has the typical form pictured in Figure 6 for all z_t in some neighborhood $(z^*(\alpha_t), z^*(\alpha_t) + \delta)$.

Write w_a for $r_a(M_q; \alpha_t, z_t)$. I first note that a number of simple comparisons imply that economists must infer that standards are lower and q is less important than they had thought. Specifically, we must have $\hat{m} > m_t$ and $\hat{w} \in (w_a, w_t)$. To see this, note first that the line given by (\hat{m}, \hat{w}) can not be entirely above the (m_t, w_t) line over the whole range $[\underline{q}(\alpha_t, z_t), t_q(\alpha_t, z_t)]$ of q -qualities of resubmitted papers. From any such estimate both L_1 and L_2 are decreased by moving the line down until there is an intersection. Next, note that it is also impossible for the minimum to have $\hat{w} > w_t$ with the (\hat{m}, \hat{w}) line intersecting the (m_t, w_t) line at $q \in [\underline{q}, t_q]$. In this case, L_1 and L_2 are both reduced by rotating the fitted line about the point where it intersects the line $r = r_a(q; m_t, w_t)$ in the direction that reduces \hat{w} . The estimates also can not have $\hat{w} < w_a$. In this case increasing \hat{w} to w_a and setting $\hat{m} = m_t$ reduces L_1 and makes L_2 equal to its global minimum. This gives $\hat{w} \in (r_a(M_q; \alpha_t, z_t), w_t)$. It is then easy to see that $\hat{m} \geq m_t$. Otherwise, slightly reducing \hat{m} would reduce L_1 and also reduce L_2 . (The latter is because the gain from to improving the fit in $(\underline{q}, \min(\bar{q}, M_q))$ is greater than the loss from worsening the fit in the (possibly empty) interval $[M_q, \bar{q}]$.) Finally, all of the extreme values ($\hat{m} = m_t$, $\hat{w} = w_t$ and $\hat{w} = w_a$) can be ruled out by looking at derivatives of the loss function.

To obtain the proposition's further conclusion that the changes in m and w are both first order in $z_t - z^*(\alpha_t)$ I examine the first order conditions of the loss function. Even after the discussion above there remain a few possibilities for exactly where the best fit line may intersect the other lines in the figure: it may be above or below $r_a(q; \alpha_t, z_t)$ at the left edge and may be above or below $r(t_q; \alpha_t, z_t)$ at the right edge. The first order conditions are slightly different in the four cases. I will work out the equations for the simplest case: assuming that the best fit line is strictly between $r_a(q; \alpha_t, z_t)$ and $r(q; \alpha_t, z_t)$ throughout the interval $[\underline{q}, t_q]$.

In this case, the loss function is very similar to the loss function in the cases above. The only differences are that the set of unexpectedly accepted papers does not have papers with q -qualities above \bar{q} and is also missing a second-order triangle in (q, r) -space below $(\bar{q}, r(\bar{q}; \alpha_t, z_t))$. As above, the second-order triangle can be ignored. The estimates have the same asymptotics as those obtained by minimizing loss functions given by integrals identical to those in part (a) but with different lower and upper bounds. Specifically we can examine the minimizer of $L = L_1 + L_2$ where

$$L_1(m, w) = \frac{1}{12}(t_q - \underline{q})^2(m - m_t)^2 + (w - w_t)^2$$

and

$$L_2(m, w) = \frac{1}{24\sigma} \frac{(\bar{q} - \underline{q})^3}{t_q - \underline{q}} (m - m_t)^2 + \frac{1}{2\sigma} \frac{\bar{q} - \underline{q}}{t_q - \underline{q}} \left(w - w_a - (m - m_t) \frac{t_q - \bar{q}}{2} \right)^2.$$

(Note that I've omitted the arguments (α_t, z_t) arguments of t_q , \bar{q} and \underline{q} to improve readability.) The first order conditions for this minimization are of the form

$$\begin{aligned} c_1(\hat{m} - m_t) - c_2(\hat{w} - w_a) &= 0 \\ -c_2(\hat{m} - m_t) + c_3(\hat{w} - w') &= 0, \end{aligned}$$

where $w' = \frac{2\sigma(t_q - \underline{q})w_t + (\bar{q} - \underline{q})w_a}{2\sigma(t_q - \underline{q}) + (\bar{q} - \underline{q})}$ is a weighted average of w_t and w_a and c_1 , c_2 and c_3 are positive constants: $c_1 = \frac{1}{6}(t_q - \underline{q})^2 + \frac{1}{12\sigma} \left(\frac{\bar{q} - \underline{q}}{t_q - \underline{q}} \right)^3 + \frac{1}{4}(\bar{q} - \underline{q})(t_q - \bar{q})$; $c_2 = \frac{(\bar{q} - \underline{q})(t_q - \bar{q})}{2\sigma(t_q - \underline{q})}$; and $c_3 = 2 + \frac{\bar{q} - \underline{q}}{\sigma(t_q - \underline{q})}$. Adding c_2/c_3 times the second equation to the first gives

$$\hat{m} - m_t = \frac{c_2 c_3}{c_1 c_3 - c_2^2} \frac{2\sigma(t_q - \underline{q})}{2\sigma(t_q - \underline{q}) + (\bar{q} - \underline{q})} (w_t - w_a).$$

We know that the true minimum has $\hat{m} > m_t$ and that $w_t > w_a$, so the first order conditions of this case can only give the true minimum if the constant in this expression is positive. The equations also give

$$\hat{w} - w_t = \frac{c_2^2 - c_1 c_3 \frac{\bar{q} - \underline{q}}{2\sigma(t_q - \underline{q}) + (\bar{q} - \underline{q})}}{c_1 c_3 - c_2^2} (w_t - w_a),$$

From the discussion above this can be the true minimum only if the leading constant is negative.

The fact that $w_t - w_a \approx (z_t - z^*(\alpha_t))/(1 - \alpha_t)$ implies that $\hat{m} - m_t$ and $\hat{w} - w_t$ are first order in $z_t - z^*(\alpha_t)$. The longer expression for $z_{t+1} - z_t$ follows from the calculation

$$\begin{aligned} \hat{z} - z_t &= \hat{\alpha} M_q + (1 - \hat{\alpha}) \hat{w} - (\alpha_t M_q + (1 - \alpha_t) w_t) \\ &= (1 - \alpha_t)(\hat{w} - w_t) + M_q(\hat{\alpha} - \alpha_t) - \hat{w}(\hat{\alpha} - \alpha_t) \\ &= (1 - \alpha_t)(\hat{w} - w_t) + (M_q - M_r)(\hat{\alpha} - \alpha_t) + (M_r - \hat{w})(\hat{\alpha} - \alpha_t) \end{aligned}$$

The last term in this expression is second order in $z_t - z^*(\alpha_t)$.

QED.

Proof of Proposition 7

(a) Recall from the proof of Proposition 6 that $t_q(\alpha_t, z_t)$ is differentiable in z at $z^*(\alpha_t)$ and that the distribution of paper qualities will also have the low α or somewhat low α form for z_t in a neighborhood of $z^*(\alpha_t)$. The same computation as in the proof of part (b) of Proposition 6 shows that for z_t in some neighborhood $(z^*(\alpha_t), z^*(\alpha_t) + \delta)$ the loss function is of the form $L = L_1 + L_2$ with

$$\begin{aligned} L_1(m, w; m_t, w_t) &= \frac{1}{12}(t_q - \underline{q})^2 (m - m_t)^2 + (w - (w_t + \epsilon))^2 \\ L_2(m, w; m_t, w_t) &= \frac{1}{24\sigma}(t_q - \underline{q})^2 (m - m_t)^2 + \frac{1}{2\sigma}(w - r_a(M_q; \alpha_t, z_t))^2. \end{aligned}$$

Differentiating, (m_t, w_t) is a steady state if and only if $w_t - r_a(M_q; \alpha_t, z_t) = 2\sigma\epsilon$. In the previous proof we also saw that $w_t - r_a(M_q; \alpha_t, z_t) \approx \frac{1}{1-\alpha_t}(z_t - z^*(\alpha_t))$. Hence, for ϵ sufficiently small we can find a $z_t > z^*(\alpha_t)$ that satisfies the equation for a steady state.

In the somewhat low α case the equations above give $z^\epsilon(\alpha) - z^*(\alpha) \approx 2(1-\alpha)\sigma\epsilon$. In the low α case we saw earlier that the expression $w_t - r_a(M_q; \alpha_t, z_t) = \frac{1}{1-\alpha_t}(z_t - z^*(\alpha_t))$ is exact when z_t is sufficiently close to $z^*(\alpha_t)$, and hence the expression for $z^\epsilon(\alpha) - z^*(\alpha)$ is an equality as well.

(b) Again for a given α_t the distribution of papers has the typical form if z_t is sufficiently close to $z^*(\alpha_t)$. For w_t in a neighborhood of $r(M_q; \alpha_t, z_t)$ and (m, w) sufficiently close to (m_t, w_t) with $m \leq m_t$, $w \geq w_t$ the expression for the loss function is again a slight variant of that in the previous proposition:

$$\begin{aligned} L_1(m, w; m_t, w_t) &= \frac{1}{12}(t_q - \underline{q})^2(m - m_t)^2 + (w - (w_t + \epsilon))^2 \\ L_2(m, w; m_t, w_t) &= \frac{1}{24\sigma} \left(\frac{\bar{q} - \underline{q}}{t_q - \underline{q}} \right)^3 (m - m_t)^2 + \frac{1}{2\sigma} \frac{\bar{q} - \underline{q}}{t_q - \underline{q}} \left(w - w_a - (m - m_t) \frac{t_q - \underline{q}}{2} \right)^2, \end{aligned}$$

where again I've written w_a for $r_a(M_q; \alpha_t, z_t)$ to save space. A direct computation shows that $\frac{\partial L}{\partial m}(m_t, w_t; m_t, w_t) = 0$ and $\frac{\partial L}{\partial w}(m_t, w_t; m_t, w_t) < 0$ when (m_t, w_t) corresponds to a consistent social norm. This is the first result mentioned in part (b).

We will find $\frac{\partial L}{\partial z} = 0$ with L parameterized by (α, z) if and only if $\frac{\partial L}{\partial w} = 0$ when L is parameterized by (m, w) . A simple calculation of derivatives shows that $\frac{\partial L}{\partial w}(m_t, w_t; m_t, w_t) = 0$ if and only if

$$w_t - w_a = 2\sigma \frac{t_q - \underline{q}}{\bar{q} - \underline{q}} \epsilon = 0.$$

As above this has a solution z_t with $z_t - z^*(\alpha_t) \approx 2(1-\alpha_t)\sigma \frac{t_q - \underline{q}}{\bar{q} - \underline{q}} \epsilon$. This establishes the next claim in part (b) and the fact that the smallest solution has $z^\epsilon(\alpha_t) - z^*(\alpha_t) \approx a\epsilon$ for some $a > 0$.

If (m_t, w_t) were a steady state of the dynamics in which the distribution of paper qualities had the typical form it would have to satisfy the first-order condition above and the additional constraint that $\frac{\partial L}{\partial m}(m_t, w_t; m_t, w_t) = 0$. We know that $\frac{\partial L_1}{\partial m}(m_t, w_t; m_t, w_t) = 0$ for any m_t and w_t . The w FOC can only be satisfied for $w_t > r(M_q; \alpha_t, z_t)$. For such values of w_t and for $m \leq m_t$ sufficiently close to m_t we have

$$L_2(m, w_t; m_t, w_t) = \frac{1}{\sigma(t_q - \underline{q})} \left(\int_{\max(0, \bar{q} - M_q)}^{(t_q - \underline{q})/2} \int_0^{(m - m_t)q} r dr dq + \int_{M_q - \bar{q}}^{(t_q - \underline{q})/2} \int_0^{w_t - w_a - (m - m_t)q} r dr dq \right).$$

The first term is the surprise due to the unexpected acceptance of papers with q -qualities above \bar{q} , and the second is the surprise due to the unexpected acceptance of papers with lower q -qualities. Evaluating the integrals and differentiating gives

$$\frac{\partial L_2}{\partial m}(m_t, w_t; m_t, w_t) = -\frac{(t_q - \underline{q})^2 - 4(\bar{q} - M_q)^2}{8\sigma(t_q - \underline{q})} (w_t - w_a).$$

The derivative with respect to α is simply this expression divided by $(1 - \alpha_t)^2$. This is negative, which is the second conclusion of part (b). It is also immediate from the expression that $\frac{\partial L}{\partial \alpha}(\alpha_t, z_t; \alpha_t, z_t) \approx b\epsilon$.

Looking at the numerator in the equation for $\frac{\partial L}{\partial m}$ we can also see that the gain from reducing α vanishes as we approach the somewhat low α region and \bar{q} approaches t_q (or as α approaches one and \bar{q} approaches \underline{q} .)

QED.

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Table 1: Mean references per nonreview article and average page lengths

Field	Journal	Pages		References	
		1975	1999	1977/8	1998
Accounting	Accounting Review	12.1	20.9	12.3	32.4
Anthropology	Current Anthropology	11.2	17.8	61.4	57.3
Anthropology	Amer. Jrn. of Physical Anthropology	8.9	14.0	26.6	47.3
Biology	Cell	9.1	11.5	35.4	49.0
Chemistry	Journal of the Amer. Chemical Society	6.4	7.9	32.8	38.6
Communication	Journal of Communication	9.0	18.6	10.0	52.7
Computer Science	IEEE Transactions on Info. Theory	7.3	13.7	17.5	23.9
Computer Science	Journal of the ACM	12.0	29.0	15.0	37.8
Computer Science	Communications of the ACM	7.6	7.0	14.6	6.9
Demography	Demography	13.7	13.5	16.9	37.5
Ecology	Ecology	9.8	12.7	33.0	56.2
Economics	Econometrica	14.8	31.1	15.1	27.2
Economics	Journal of Political Economy	22.2	29.7	18.0	29.7
Economics	Quarterly Journal of Economics	15.5	36.7	15.9	31.2
Economics	Review of Economic Studies	12.9	23.5	12.2	29.2
Education	American Educational Research Journal	15.0	36.4	19.4	50.7
Education	Harvard Educational Review	23.8	26.8	47.2	43.7
Eng. - Aero.	AIAA Journal	5.8	7.8	11.5	21.4
Eng. - Elec.	IEEE Transactions on Electron Devices	6.6	7.2	13.9	17.7
Eng. - Materials	Journal of Materials Science	7.7	7.8	18.0	21.6
Eng. - Mech.	Journal of Eng. Mechanics and ASCE	15.3	8.5	14.9	19.2
Finance	Journal of Finance	13.9	34.8	15.0	30.8
Geography	Ann. of the Assoc. of Amer. Geographers	12.7	24.4	37.1	67.1
Geology	Geology	4.8	4.0	19.8	25.2
Geology	Journal of Geology	17.8	15.3	35.7	50.7
History	American Historical Review	22.5	31.0	85.9	62.7
History	Journal of American History	22.8	28.4	75.2	65.9
Law	Harvard Law Review	59.1	92.4	156.6	47.7
Law	Yale Law Journal	56.2	85.4	165.9	59.1
Linguistics	Language	18.8	^a 30.1	30.9	61.2
Mathematics	Annals of Mathematics	21.6	35.0	18.0	28.4
Mathematics	Inventiones Mathematicae	22.7	34.6	16.1	25.2
Medicine	New England Journal of Medicine	4.0	7.2	23.0	24.9
Medicine	Journal of the Amer. Medical Assoc.	4.1	6.6	9.5	24.2
Oceanography	Limnology and Oceanography	10.2	11.3	26.5	42.3
Paleontology	Journal of Paleontology	13.8	12.8	19.2	45.4
Philosophy	Philosophy of Science	15.8	20.6	16.0	32.3
Physics	Physical Review Letters	3.3	4.0	15.4	20.8
Physics	Physical Review B	8.9	8.5	25.4	28.6
Physics	Physical Review D	8.9	10.7	22.9	31.5
Political Science	American Journal of Political Science	16.9	24.2	27.6	37.2
Political Science	American Political Science Review	12.7	^a 16.1	37.1	51.0
Psychology	Psychological Review	21.6	^a 30.3	51.4	60.0
Psychology	Journal of Personality and Social Psych.	8.3	14.4	23.8	59.3
Psychology	Developmental Psychology	7.8	11.5	12.6	45.8
Sciences	Nature	4.2	5.7	17.8	25.8
Sciences	Science	7.7	5.5	23.3	28.5
Sociology	American Sociological Review	15.5	17.2	35.8	49.2
Sociology	American Journal of Sociology	22.7	39.3	26.2	60.1
Statistics	Journal of the Amer. Statistical Assoc.	5.9	11.5	13.5	28.3
Women's Studies	Signs	22.1	31.0	22.5	48.5

Notes: *a* - Data not adjusted for larger page size.

Table 2: Duration of the review process at various journals: 1975 and 1999

Field	Journal	Mean delay	
		1975	1999
Mean submission-final resubmission time			
Biology	Cell	1.2	2.2
Computer Science	IEEE Transactions on Info. Theory	6.9	13.6
Computer Science	Journal of the ACM	10.4	21.0
Economics	Econometrica	9.3	26.3
Eng. - Aero.	AIAA Journal	5.3	8.7
Eng. - Elec.	IEEE Transactions on Electron Devices	4.6	6.0
Eng. - Elec.	Proceedings of the IEEE	2.6	6.9
Eng. - Materials	Journal of Materials Science	1.5	5.2
Finance	Journal of Finance	^a 6.5	18.6
Mathematics	Annals of Mathematics	2.0	5.5
Mathematics	Inventiones Mathematicae	1.3	10.8
Philosophy	Philosophy of Science	0.9	5.8
Physics	Physical Review B	0.4	1.3
Political Science	American Journal of Political Science	6.0	7.6
Psychology	Psychological Review	1.7	18.8
Statistics	Annals of Statistics	15.0	18.0
Statistics	Journal of the Amer. Statistical Assoc.	10.1	18.6
Stat. - Bio.	Biometrika	5.3	15.1
Stat. - Psych.	Psychometrika	8.1	16.8
Mean submission-acceptance time			
Ecology	Ecology	8.9	^b 9.2
Economics	Quarterly Journal of Economics	8.5	13.0
Economics	Review of Economic Studies	12.1	28.8
Geology	Geology	2.2	4.6
Oceanography	Limnology and Oceanography	7.0	^c 8.8
Mean submission-publication time			
Astronomy	Astrophysical Journal	7.9	10.7
Chemistry	Journal of the Amer. Chemical Society	7.8	6.2
Geology	Journal of Geology	12.4	10.6
Linguistics	Language	12.8	24.8
Philosophy	Philosophy of the Social Sciences	13.8	22.1
Physics	Physical Review Letters	2.1	5.8
Psychology	Developmental Psychology	9.8	24.1
Sciences	Nature	4.3	4.3

Notes: *a* - Data for 1979. *b* - Does not include time for post-acceptance revisions (which occurred for about 40% of papers.) *c* - Does not include time for post-acceptance revisions (which occurred for about 90% of papers.)