Congestion in academic journals
under an impartial selection process

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Abstract

This paper studies the congestion of an academic journal in the publishing game played by researchers and editors. When the number of submitted papers exceeds the number of reliable referees, editors have no option but to send papers to poorly reliable reviewers. However, faced to questionable reports, an impartial editor may wish to correct some of the bad referees' decisions in order to match the frequency of accepted papers with the frequency of the good submitted papers. In this game, a separating equilibrium always exists in which only good researchers submit their papers to the journal, each paper is accepted and the quality of the journal reaches its highest level. However when the reward of refereed publications exceeds a given threshold, two hybrid equilibria are also feasible. In these equilibria bad researchers submit their papers to the journal and, as the flow of papers exceeds the availability of good referees, the refereeing process becomes imperfect. This gives a chance to low-quality papers to get published by the journal. As expectations are self-fulfilling the researchers' beliefs concerning the quality of the editorial process determines the effective quality of the review. The various strategies implemented by the editors to oppose congestion are then discussed.

Keywords: Publication market, Academic journals, Editors, Congestion.

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Section 1: Introduction

Following the trend set by the US many years ago, European and Asian governments are undertaking an institutional transformation of their research environment. The reforms aim at increasing the quantity and quality of research through performance-based reward schemes and enhancement of the role of research in the public evaluation process (Geuna and Martin. 2003). In this process, academic publications tend to become the major indicator of research performance. As a result, competition for inclusion in the high impact peer-review academic journals becomes more intense and highly-cited journals attract more and more submissions[4]. If this evolution reflects a desirable growth of knowledge production, it also presents adverse effects for the management of academic journals.

The editorial selection process is intrinsically imperfect. Journals may sometimes reject good papers and accept poor contributions to the scientific debate[5]. Moreover, dealing with an increasing number of submissions, editors may face a shortage of resources required by the evaluation procedures. They may, for instance, be forced to ask reports from researchers whose expertise or motivation cannot be properly assessed (Tsang and Frey 2007). In this case, that could be referred to as the congestion of the editorial process (Goel and Faria 2007), the efficiency of the papers' selection may be dramatically challenged**.**

In answer to this editorial congestion, editors of top-tier journals start to implement defence strategies, some of them running against the transparency of the publication process (Bence and Oppenheim 2004a, 2004b). In order to prevent submission of low quality papers, editors generally raise the costs paid by the authors in case of rejection. For example, a long time lag between the submission and the first decision, as it postpones the possibility of publication in other journals and the reward that could come with the publication, may deter low quality articles of being submitted (Elisson 2002, Azar 2005). The increase in submission fees appears to be an alternative efficient device to reduce the flow of submissions (Wang 1997, Leslie 2005, Azar 2006). More recently, desk rejection policies tend to be implemented by an increasing number of journals (Besancenot et alii 2011)[6]. The editor may then decide to return a manuscript without

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[4]For instance, the Editor Report 2010 of the American Economic Review states that the number of submissions to the journal has increased from 641 in 1980 to 1398 in 2009 for a stable number of published papers (*The American Economic Review*, Report of the Editor, January 2, 2010).

[5] This assumption is empirically verified by Oswald (2007) or Cherkashin et al. (2009) who show that the best article in a medium quality journal can be more influential than the worst articles in an issue of a top tier journal. See also Gans and Shepherd (1994) for a description of the difficulties encountered by famous seminal papers to be published.

[6] See for instance the Instruction to Authors web page of Econometrica, Journal of Monetary Economics Scandinavian Journal of Economics or The American Economic Review.

review on the basis of various considerations, including expected probability of meeting the standards of the Journal, breadth of topic, interest to the journals audience. While these measures do oppose the congestion effect, they clearly convey an image of unfairness and lack of transparency.

This paper aims at considering the potentially detrimental effects of the increase in the number of submissions on the quality and the suitability of the papers' selection by the editors of academic journals. In this purpose, our paper develops a highly stylized model to study the publishing game played by researchers and editors[7]. It analyzes the conditions for congestion to appear in the editorial process and studies the effects of a rise of the rejection costs as a solution to avoid the congestion effect.

The main argument of this paper follows an idea close to McCabe and Snyder (2005) and Besancenot and Vranceanu (2008b) in which the editors can only imperfectly determine an article's quality. It considers researchers who may publish their paper either in a book or in a refereed journal. Publishing an article in an academic journal has greater value, however the selection process is risky and a rejection is costly for a researcher.

In our paper, the quality of the refereeing process relies on the number of submissions received by the Journal. The editor who receives a paper ignores the quality of the paper and, in order to make her decision, she sends the paper to a referee in charge of the paper's evaluation. The editor has at her disposal a pool of reviewers that splits into two groups. A first group of referees have a faultless judgement. They can identify a paper's quality without error, rejecting poor papers and accepting good ones. These referees are perfectly known by the editor: they may be close colleagues from the same university or institution, regular authors of a journal or identified specialists of the field, in sum, they are members of the same academic network (Van Dalen 1999, Faria, 2002). However, the set of academic fellows in which an editor can have an absolute trust is bounded and, even in asking more than one report to each of these referees, the maximum number of trustable referee reports that an editor can ask for is limited. When the number of submissions exceeds this maximum number of good referee reports, the editor will have difficulties to obtain reviews from individuals with appropriate expertise (Hochberg et alii. 2009) [8]. In this case, the editor is forced to rely upon reviewers of the second group. However, these referees are less reliable: some of them will be prone to accept any kind of paper (they are

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[7] See Faria (2005) for an alternative analysis of the game between editors and researchers.

[8] Bedeian (2003) stresses that editors do not necessarily know who is a competent referee in a particular area. In his survey, 54.7% of the authors recognized that they had been asked to referee a manuscript they were not competent to critique and more than one third (36.6%) reported that they still accepted to review the paper.

afraid of rejecting a good paper) while others will reject most of the submitted papers (to avoid the risk of accepting a bad paper). Thus, when no good referee is available, the editor may wish to correct some of the bad referees' decisions. She will accept some papers rejected by too demanding referees and reject some of the papers accepted by referees that seem too indulgent.

A main assumption of the paper is that editors are seeking for fairness. As a gap between the frequencies of accepted papers by the two groups of referees would reveal a bias in favour of either rejection or acceptation, an impartial editor should correct the bad referees' decision in order to match the frequency of their accepted papers with the frequency of acceptation by good referees. Hereafter, this correction will be referred to as the *impartial selection process[9]:*

The basic result of the editorial game under the *impartial selection assumption* is twofold. The first point is that when the editor can call for a sufficient (but reasonably low) number of good referee reports, a separating equilibrium always exists whatever the values of other parameters. In this equilibrium, good researchers and only good researchers submit their papers to the journal and each paper is accepted. As a result, the quality of the journal reaches its highest level. The second result is that when the reward of refereed publications exceeds a given threshold, the selection process may be subject to congestion and two hybrid equilibria are feasible. In these equilibria bad researchers submit their papers to the journal hopping to get published and, as the flow of papers exceeds the availability of good referees, the refereeing process becomes imperfect. This gives a chance to low-quality papers to get published by the journal.

As usual in case of multiple equilibria, expectations are self-fulfilling. The researchers' beliefs concerning the quality of the editorial process determines the effective quality of the journal. Given the selected equilibrium, the model allows a discussion of the various policies implemented by editors to avoid the congestion effect.

The paper is organized as follows. Section 2 introduces the main assumptions and analyzes researchers' payoffs. Section 3 presents the typology of equilibria and comments on their basic features. Section 4 provides a discussion of the results and a last section summarizes our conclusions.

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[9] The assumption of impartiality in decision making has been introduced by Besancenot and Vranceanu (2008a) in the description of a judge behaviour seeking for impartial justice under congestion of the court.

Section 2: The model

We consider a population of researchers of dimension one. Each researcher is endowed with a paper and has to choose a publication strategy.

There are two types of papers, the *g-type* (for "good"), which are high quality papers, and the *b-type* (for bad), which are low-quality papers that do not satisfy the quality standards for publication in a refereed journal. In order to simplify the presentation, hereafter we will refer to *g-type* researcher (resp. *b-type*) for an academic fellow endowed with a good (resp. bad) paper. The frequency of *g-type* papers (resp. *b-type*) in the total set of papers is denoted by α (resp. $1-\alpha$), with $0 < \alpha < 1$. With a population of researchers of dimension one, α is also the number of *g-type* papers in the economy.

A researcher perfectly knows the quality of his paper. He can either submit this paper to an academic journal (J-strategy) or publish it in a book (B-strategy). Whatever its type, a paper's quality is sufficient to guarantee a publication in a book. Thus the B-strategy leads to the certain reward W^b. A researcher playing the J-strategy sends his paper to the editor of an academic journal. If the paper is accepted for publication, the reward is W^j with $W^j > W^b$. However, the paper may be rejected and the author has no alternative other than to publish the paper in a book. In this case, the reward will be $W^b - c$ where c denotes the cost for the researcher of an unsuccessful submission (i.e. the sunk submission fee, the frustration of being rejected or the financial consequences of a delayed publication).

Good referees come from a pool of high-skilled researchers (a small subset of authors). Let us denote by θ the maximum number of reports that the editor can ask from these referees. In the following we will restrict our arguments to the non trivial case where $\alpha \leq \theta < 1/2$. There is at least as much good referee reports as good papers[10] and the editor cannot affect a good referee to more than half of the total number of papers.

The model can be cast as a sequential game featuring two rational players: the researcher, who chooses his publication strategy, and the journal's editor who decides to publish or not the submitted papers. The typical sequence of decisions is the following:

Time $t = 0$, nature chooses the type of paper that the researcher will have to manage.

Time $t = 1$, the researcher decides which of the two publication strategies he will implement. He can publish his paper in a book and receive W^b. (in this case, the game is over) or send it to

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[10] Under $\alpha > \theta$ the separating equilibrium would not exist.

the editor and wait for her decision.

Time $t = 2$, the editor who receives a paper sends it to a referee. With a probability P, the paper will be evaluated by a good reviewer, and with a probability $(1 - P)$ the paper is evaluated by a bad one.[11] Hereafter, P will be endogenously defined according to the relative number of submissions and good referees.
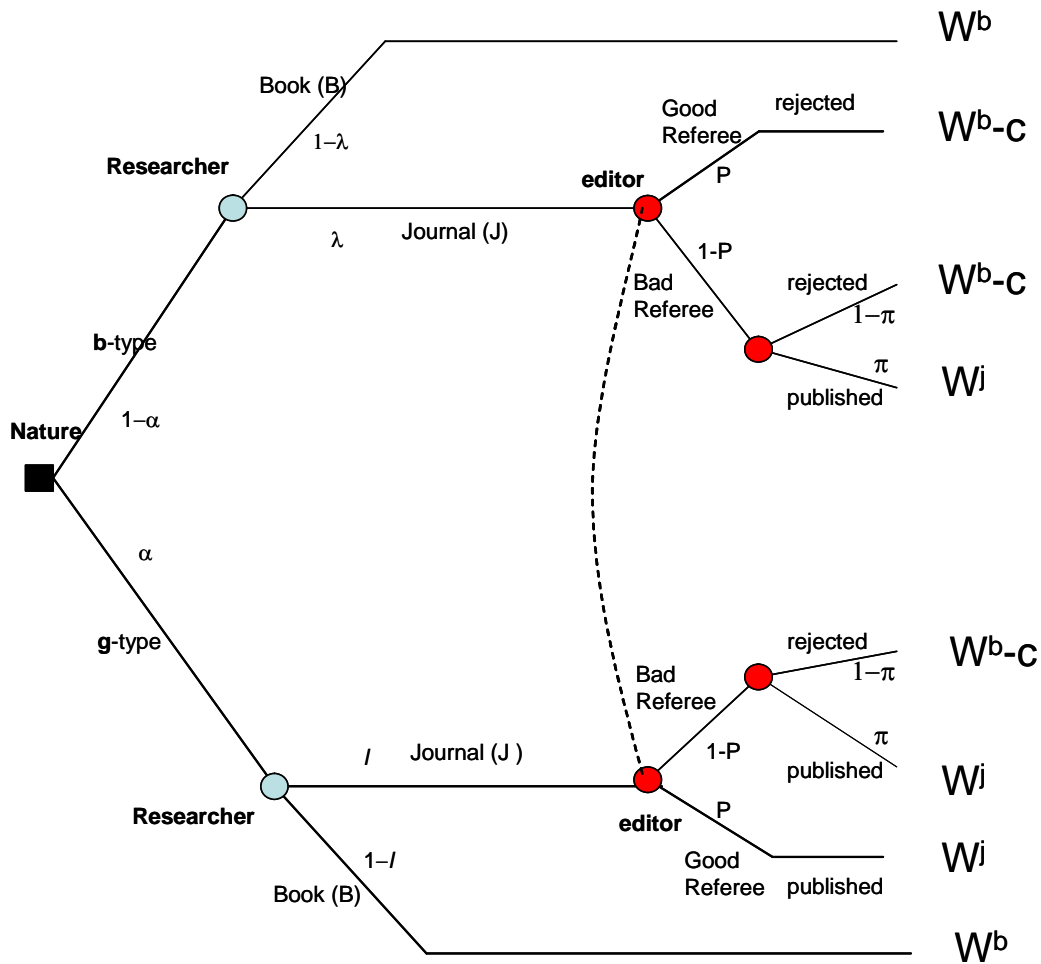

Fig. 1

Time $t = 3$, when the reviewer is good, the editorial decision perfectly reflects the quality of the paper. A *b-type*'s paper will be rejected (its author will receive $W^b - c$), and a *g-type* paper

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[11]By assumption, the choice of the referee is random; the editor cannot assign good reviewers to good authors (Cf. Hamermesh 1994).

6

will be accepted (its author will receive W^j). When the referee is a bad one, the editor may refuse to follow his decision[12]. According to the *Impartial selection* assumption, making her own evaluation of the paper, the editor adjusts the frequency of the accepted papers to match it with the *g-type* papers frequency.[13] In order to present the results in a simple way, we assume that, in this case, the paper is accepted with a probability π equal to the frequency of *g-type* in the set of submitted papers whatever its quality.

Figure 1 presents the decision tree of the game.

The *Impartial selection* assumption is clearly a radical idealization of the true selection process. Faced to a non reliable referee, an efficient editor will correct the decision according to her own assessment of the paper and the acceptation probability should be linked to the quality of the paper. However, our assumption presents some interesting properties that reflect the true selection process.

First, this assumption allows considering a downgrading precision of the editors as the number of bad submissions increases. If the selection of the highest quality papers is certainly possible when the editor has only a few papers to reassess, in case of congestion of the editorial process the time that an editor may spend on each paper drops and the precision of the editors judgment decreases. In this case, the acceptance of low quality papers on a timely topic as well as the rejection of good but technical papers in topics out of the expertise field of the editor can both be feasible. This imprecision introduces a random dimension in the editorial decision that is captured by our assumption. In the model, the probability of publication of a b-type paper increases with the fraction of b-type papers submitted to the journal.[14]

Second, our assumption adequately formalizes part of the editor's rationality. Indeed, when the journal receives no bad paper, case π=1, a rational editor should be disposed to publish every submitted papers and the overall frequency of the accepted papers should be equal to one. In the opposite limiting case, with a frequency of good papers' submission close to 0, an editor should be prompt to correct the bad referees' advices in a very restrictive way and to accept a given paper with a probability close to 0. In both cases, editorial rationality is captured by our assumption.

Let us denote by l (resp. λ) the probability that a researcher endowed with a *g-type* paper (resp. a *b-type*) plays the J-strategy and by $(1-l)$ (resp. $1-\lambda$) the probability of the B-strategy.

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[12] According to Starbuck (2003), if the editorial golden rule should be "No reviewer is ever wrong!", this rule does not assert that the editor should always follow reviewers' advice.

[13] Remark that this frequency is known by the editor who observes the rate of rejection by good referees.

[14] Introducing the possibility for an editor to perfectly identify a finite number of papers would not change the main results of the paper.

According to these probabilities, the number of journal submissions is given by $\alpha l + (1-\alpha)\lambda$, and the probability P for a submitted paper to be evaluated by a good referee is:

$$P = \min\{1, \frac{\theta}{\alpha l + (1-\alpha)\lambda}\} \tag{1}$$

According to the *impartial selection assumption,* the frequency π of papers accepted by the journal matches the frequency of *g-type* papers in the set of submitted papers, so:

$$\pi = \frac{\alpha l}{\alpha l + (1-\alpha)\lambda}, \tag{2}$$

Thus, the expected payoffs $E[U^g \mid s]$ for a *g-type* researcher playing strategy s are:

$$E[U^g \mid s = B] = W^b$$
$$E[U^g \mid s = J] = PW^j + (1-P)\big[\pi W^j + (1-\pi)(W^b - c)\big]$$
$$= W^j - \frac{(1-\alpha)\lambda}{\alpha l + (1-\alpha)\lambda}\left(1 - \min\{1, \frac{\theta}{\alpha l + (1-\alpha)\lambda}\}\right)\big[W^j - W^b + c\big], \tag{3}$$

and the expected payoffs $E[U^b \mid s]$ for a *b-type* researcher are given by:

$$E[U^b \mid s = B] = W^b$$
$$E[U^b \mid s = J] = P(W^b - c) + (1-P)\big[\pi W^j + (1-\pi)(W^b - c)\big]$$
$$= (W^b - c) + \frac{\alpha l}{\alpha l + (1-\alpha)\lambda}\left(1 - \min\{1, \frac{\theta}{\alpha l + (1-\alpha)\lambda}\}\right)\big[W^j - W^b + c\big] \tag{4}$$

Section 3: Equilibria*:*

We can study now the Perfect Bayesian Equilibria of the game. An equilibrium is defined here as a situation where the researchers, expecting their colleagues to play a given strategy, carry out optimal strategies coherent with their expectations.

Remark first that, in this game, the J-strategy is strictly dominant for a *g-type* researcher. Indeed, the expected reward of a submission to the journal is higher for the writer of a good paper than for the author of a poor one, $E[U^b \mid s = J] < E[U^g \mid s = J]$. If, for a *g-type* researcher, the reward of a publication in a book was superior or equal to the reward expected from a submission in an academic journal, i.e. $E[U^g \mid s = B] \geq E[U^g \mid s = J]$, this journal would receive no submission from a b-type researcher, $\lambda = 0$. But, in this case, according to Eq. (1), *P=1,* and, the *g-type* researcher would be sure both to be reviewed by a good referee and to be accepted for publication in case of submission. The condition, $E[U^g \mid s = B] \geq E[U^g \mid s = J]$,

thus requires $W^j \leq W^b$, which contradicts our assumption about these values. The reward of a publication in a book cannot be superior or equal to the reward expected from a submission in an academic journal

With *g-type* researchers always playing the dominant J-strategy, we must have $l = 1$, and the set of equilibria of the game restricts itself to a separating, a pooling, and two hybrid equilibria. As the pooling equilibrium appears to be the limiting case of one of the two hybrids, this equilibrium will be presented in the appendix.

Separating equilibrium

In this first equilibrium, *g-type* researchers submit to the journal and *b-type* publish in books, thus researchers' beliefs are*:* $\lambda = 0, l = 1$

For a *b-type* researcher, these beliefs imply:

$$E[U^b \mid s = J] = \left(W^b - c\right) + \left(1 - \min\{1, \frac{\theta}{\alpha}\}\right)\left[W^j - W^b + c\right] \tag{5}$$

As $\min\{1, \frac{\theta}{\alpha}\} = 1$, the expected reward of a submission to the journal is $E[U^b \mid s = J] = \left(W^b - c\right)$. Obviously, the *b-type* researcher will prefer to publish his paper in books. For both types of researchers, optimal strategies are consistent with the equilibrium beliefs.

Remark that this equilibrium is always feasible under the sufficient condition*:* $\min\{1, \frac{\theta}{\alpha}\} = 1$, i.e. if $\theta \geq \alpha$. This condition states that as long as the number of good reviewers exceeds the number of submitted papers, any low quality paper will be rejected. The papers selection process is perfectly efficient and there is no incentive for a bad researcher to submit a paper to the refereed journal. The journal receives and publishes only good papers.

Hybrid equilibria

The model also allows equilibria in which b-type researchers, indifferent between the two strategies, randomly adopts the B- or the J-strategy. In this case, researchers' beliefs are given by*:* $\lambda \in [0,1]$ and the expected payoffs of the J-strategy are*:*

$$E[U^b \mid s = J] = \left(W^b - c\right) + \frac{\alpha}{\alpha + (1-\alpha)\lambda}\left(1 - \frac{\theta}{\alpha + (1-\alpha)\lambda}\right)\left[W^j - W^b + c\right] \tag{6}$$

For the *b-type* researcher the indifference between the two strategies, $E[U^b \mid s = B] = E[U^b \mid s = J]$, implies*:*

9

$$W^b = (W^b - c) + \frac{\alpha}{\alpha + (1-\alpha)\lambda}\left(1 - \frac{\theta}{\alpha + (1-\alpha)\lambda}\right)\left[W^j - W^b + c\right] \tag{7}$$

Note that this condition can only be true if $\dfrac{\theta}{\alpha + (1-\alpha)\lambda} < 1$, i.e. if $P < 1$. After some

manipulations, Eq. (7) can be stated as:

$$0 = c(\alpha + (1-\alpha)\lambda)^2 - (\alpha + (1-\alpha)\lambda)\alpha\left[W^j - W^b + c\right] + \theta\alpha\left[W^j - W^b + c\right] \tag{8}$$

$$\Leftrightarrow 0 = cx^2 - xy + \theta y \text{ with } \begin{cases} y = \alpha\left[W^j - W^b + c\right] > 0 \\ x = (\alpha + (1-\alpha)\lambda) \end{cases}$$

This equation presents two solutions for x and implies two solutions for λ :

$$x_{1,2} = \frac{y \pm \sqrt{y^2 - 4c\theta y}}{2c} \Rightarrow \begin{cases} \lambda_1 = \left[y - 2c\alpha - \sqrt{y^2 - 4c\theta y}\right]/2c(1-\alpha) \\ \lambda_2 = \left[y - 2c\alpha + \sqrt{y^2 - 4c\theta y}\right]/2c(1-\alpha) \end{cases}, \tag{9}$$

with $\lambda_1 < \lambda_2$. Note that these two roots exist if and only if $y > 4c\theta$. For $y = 4c\theta$. Eq.(8)

presents only one solution with $\lambda_0 = (2\theta - \alpha)/(1-\alpha)$.

In the model, $P < 1$ implies: $\lambda > (\theta - \alpha)/(1-\alpha) > 0$, a condition that is satisfied with any of

the two values of λ if:

$$\lambda_1 > \frac{\theta - \alpha}{(1-\alpha)} \Leftrightarrow \frac{y - 2c\alpha - \sqrt{y^2 - 4c\theta y}}{2c(1-\alpha)} > \frac{\theta - \alpha}{(1-\alpha)}$$

$$\Leftrightarrow y - 2\theta c - \sqrt{(y - 2\theta c)^2 - (2\theta c)^2} > 0 \tag{12}$$

This condition is verified for $y > 4c\theta$, in this case, the two roots are positive, $0 < \lambda_1 < \lambda_2$, and

the congestion of the editorial process is feasible. We now have to define the range of parameter

under which, $\lambda_1 < 1$ or $\lambda_2 < 1$.

Hybrid 1: $\lambda_1 \in [0,1]$

By definition: $\lambda_1 < 1 \Leftrightarrow y - 2c - \sqrt{y^2 - 4c\theta y} < 0$, two cases are possible.

- Case 1: $y - 2c \leq 0$. In this case, the inequality $\lambda_1 < 1$ is always true. As, $y > 4c\theta$, this

condition implies $4c\theta < y \leq 2c$, which is possible as $\theta < 0.5$. In this case, $\lambda_1 \in [0,1]$ is feasible

under the necessary condition:

$$4c\theta < y \leq 2c \Leftrightarrow c\frac{(4\theta - \alpha)}{\alpha} < \left[W^j - W^b\right] \leq c\frac{(2-\alpha)}{\alpha} \tag{13}$$

- Case 2: $y - 2c > 0$. Remark first that, in this case, the condition $y > 4c\theta$ is always

10

satisfied (by assumption $\theta < 0.5$). Moreover, by definition of y, the condition $y - 2c > 0$ is equivalent to:

$$c\frac{(2-\alpha)}{\alpha} < \left[W^j - W^b\right], \tag{14}$$

but $\lambda_1 < 1$ implies $y - 2c - \sqrt{y^2 - 4c\theta y} < 0$, an inequality which can be written after simplification a $c < y(1-\theta)$, which in turn is equivalent to:

$$c\frac{(1-\alpha(1-\theta))}{\alpha(1-\theta)} < \left[W^j - W^b\right] \tag{15}$$

It is easy to check that, with $\theta < 0.5$, condition (15) is satisfied when (14) is true.

Finally, mixing conditions for $\lambda_1 < 1$ in Case 1 and Case 2, we get the necessary and sufficient condition [NSC] for $0 < \lambda_1 < 1$:

$$NSC: \qquad \left[W^j - W^b\right] > c\frac{(4\theta - \alpha)}{\alpha} \tag{16}$$

In this range of parameters, differentiation of Eq. (8) and (9) allows to check that an increase of the cost c would induce a rise of the *b-type* submissions, $d\lambda_1 / dc > 0$, and that a drop of the reward W^j would produce the same result: $d\lambda_1 / dW^j < 0$.

$$\frac{d\lambda_1}{dc} = \frac{\left[(1-\alpha)\lambda_1(\alpha + (1-\alpha)\lambda_1) + \theta\alpha\right]}{(1-\alpha)\sqrt{y^2 - 4c\theta y}} > 0$$

$$\frac{d\lambda_1}{dW^j} = -\frac{\alpha}{(1-\alpha)2c}\left(\frac{y - 2c\theta - \sqrt{y^2 - 4c\theta y}}{\sqrt{y^2 - 4c\theta y}}\right) < 0 \tag{17}$$

Hybrid 2: $\lambda_2 \in [0,1]$

Condition $\lambda_2 < 1$ is equivalent to $y - 2c + \sqrt{y^2 - 4c\theta y} < 0$, a condition that can only be satisfied if $y - 2c$ is negative, which implies that $c > y/2$. After some simplifications, the first inequality appears to be equivalent to $c > (1-\theta)y$ (a sufficient condition for $c > y/2$). The necessary condition for $0 < \lambda_2 < 1$ is thus (remark that condition $y/4\theta \geq (1-\theta)y$ is verified whatever the parameter value):

$$\frac{y}{4\theta} > c > (1-\theta)y \tag{18}$$

After substitution of y by its definition, this last equation leads to the necessary and sufficient

11

condition for $0 < \lambda_2 < 1$:

$$\frac{(4\theta - \alpha)}{\alpha} c < \left[W^j - W^b\right] < \frac{(1 - \alpha(1 - \theta))}{\alpha(1 - \theta)} c \qquad (19)$$

Remark that $\lambda_2 = 1$ when $\left[W^j - W^b\right]$ reaches the upper bound. The pooling equilibrium appears to be the limiting case of the hybrid 2 equilibrium.

Finally, the differentiation of Eq. (8) allows to check that, in this equilibrium, an increase of the cost c would induce a drop of the *b-type* submissions, $d\lambda_2 / dc < 0$ and that a rise of the reward W^j would produce the opposite result: $d\lambda_2 / dW^j > 0$:

$$\frac{d\lambda_2}{dc} = -\frac{\left[(1 - \alpha)\lambda_2\left(\alpha + (1 - \alpha)\lambda_2\right) + \theta\alpha\right]}{(1 - \alpha)\left[\sqrt{y^2 - 4c\theta y}\right]} < 0$$

$$\frac{d\lambda_2}{dW^j} = \frac{\alpha}{(1 - \alpha)2c}\left(\frac{y - 2c\theta + \sqrt{y^2 - 4c\theta y}}{\sqrt{y^2 - 4c\theta y}}\right) > 0 \qquad (20)$$

Figure 2. presents the feasible values of λ_1 and λ_2 according to the value of $\left[W^j - W^b\right]$.

Section 4: Discussion

In the previous section, we established the necessary conditions for the existence of three different equilibria. For a low spread between the rewards W^j and W^b, i.e. for $\left[W^j - W^b\right] < \frac{(4\theta - \alpha)}{\alpha} c$, the only feasible equilibrium is the separating one. When the spread exceeds the previous threshold, three equilibria coexist.

In the range, $\frac{(4\theta - \alpha)}{\alpha} c < \left[W^j - W^b\right] < \frac{(1 - \alpha(1 - \theta))}{\alpha(1 - \theta)} c$, the separating equilibrium is still feasible, however the hybrid equilibria where the *b-type* researcher plays the J-strategy with either probability λ_1 or λ_2 also exists. Moreover, when $\frac{(1 - \alpha(1 - \theta))}{\alpha(1 - \theta)} c < \left[W^j - W^b\right]$, the hybrid 2 degenerates into a pooling equilibrium, an equilibrium that coexists with the separating and the Hybrid 1 equilibria.
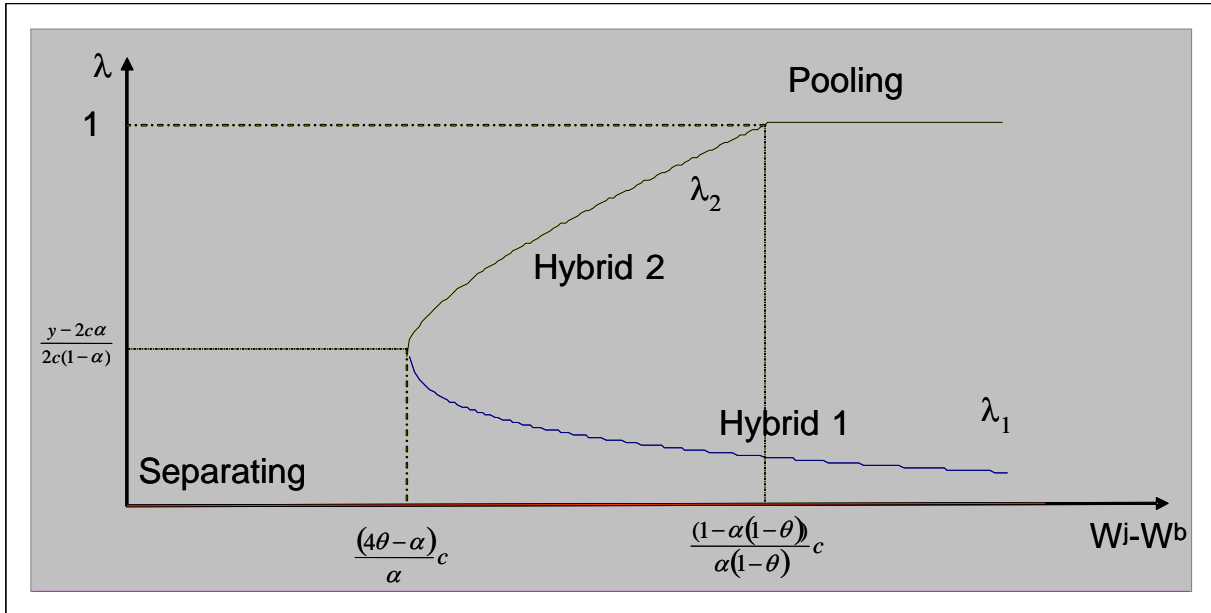
12

Fig. 2

In case of multiple equilibria, the prevailing equilibrium relies on the players' beliefs. As long as researchers expect a perfect refereeing process, they do not submit b-type papers. In this case, submission is restricted to the sole *g-type* papers. The editor receives a low number of submissions and may only call for efficient reviewers. Expectations are self-fulfilling. On the opposite, when a researcher believes that the papers' selection is imperfect, he may submit a low quality paper hoping that the overwhelmed editor will send it to an inaccurate referee. Massive submissions from *b-type* researchers thus lead to the congestion of the editorial process and induce the deterioration of the selection process.

Since academic publications tend to become the most prevalent measure of research performance, the value of a publication in a scientific journal is steadily increasing and, as a result, the number of submissions is growing at a dramatic speed. According to our model, as long as the submitted papers are of the *g-type*, this does not affect the quality of academic journals. However, when the reward of peer reviewed publications exceeds the threshold $W^b + (4\theta - \alpha)c/\alpha$, some authors may also submit their *b-type* papers to the academic journal. When this occurs, the quality of the selection process is being severely challenged and the mean quality of the published papers drops.

Note that the switch from an equilibrium to another is not continuous*:* as λ jumps from zero to a strictly positive value, the quality of the published papers drops sharply. Of course, such a change implies the implicit coordination of the b-type researchers who must collectively decide

13

to submit their paper to the Journal, but this coordination is made easier by the increase of the publication reward.

In the model, the two hybrid equilibria do not exhibit the same properties: while Hybrid 2 is stable, Hybrid 1 is not. In order to check this result, consider an increase in the reward W^J of a refereed publication. In both equilibria this change comes associated with an increase in the expected utility of a submission to the journal and, in response, the frequency λ of b-type submissions rises. However, an increase in λ generates two opposite consequences for the probability of publication by the journal. It raises the probability $(1-P)$ of being refereed by a bad referee and simultaneously drops the probability π of being accepted by the editor in case of bad refereeing. Depending on the relative importance of these two changes, the rise in λ comes with an increase or a drop in the journal probability of publishing b-type papers.

In the hybrid equilibrium 2, the rise of λ_2 implies a decrease in the probability of publication for bad papers[15]. In turn, this reduces the expected reward of submission to the journal for a b-type researcher and progressively offsets the initial increase of this reward. The model converges toward a new equilibrium value with a higher λ_2.

The opposite effect is at work in the hybrid 1 equilibrium in which a higher propensity λ_1 for a researcher to submit its b-type paper increases the probability of publication for these papers. This reinforces the incentive for b-type researchers to submit their paper and contributes to a cumulative increase in λ . This effect is self sustaining until λ reaches the threshold $\lambda = \lambda_0$, value for which any further increase in λ would induce a drop in the probability of b-type papers publication. The model then converges toward a type 2 hybrid equilibrium.

In this model, the equilibrium values λ_1 define the frontier of the λ values leading to the hybrid 2 or the separating equilibrium. For any values of the parameters, an initial situation with $\lambda > \lambda_1$ (respectively $\lambda < \lambda_1$) would degenerate to an hybrid 2 equilibrium (resp. a separating equilibrium). As λ_1 is a decreasing function of the expected reward W^J of a refereed publication, the higher this reward the easier for b-type researchers to coordinate on the hybrid equilibrium and to provoke the congestion of the editorial system.

As a response to the increase of the number of submissions, a possible editor reaction is to increase the cost *c* paid by the researchers in case of rejection. The increase of the fees, the

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[15] The derivative of $\pi(1-P)$ with respect to λ is negative under condition $\lambda > \lambda_0$, which is true for any λ in the hybrid 2 equilibrium and positive under condition $\lambda < \lambda_0$, which is true for any λ in the hybrid 1 equilibrium.

rise of the mean time before first answer, or the decreasing content of the referee reports are the main usual solutions to foster self-selection and to reduce the propensity of researchers to submit their *b-type* papers (Moyer and Crockett 1976, Leslie 2005, Azar 2005, 2006).

In our model, an increase of these costs presents two consequences: it reduces the range of the parameters that are consistent with the hybrid equilibrium (the value $\frac{(4\theta-\alpha)}{\alpha}c$ increases) and, in case of congestion, it contributes to the reduction of the frequency of b-type papers' submissions. It thus appears as an efficient device to limit the adverse effects of congestion. However, the manipulation of these costs may be a double-edged sword. Indeed rising the submission fees or delaying the first answer are both a device against congestion and a signal that this congestion could occur. It may thus contribute to the building of beliefs that will induce b-type researchers to submit their paper and foster congestion.

Another remedy is for the editor to pre-assess the quality of a paper, limiting external assessments to those papers that have a better chance of being of the top quality. Indeed, editors who decide first which papers will be send to referees may keep in the selection process a number of papers that exactly fits with the number of trustable reviewers. Papers assessment would then be made by efficient referees and the probability of a bad paper publication would reach its lowest level. Moreover, as self selection would prevent bad paper to be submitted the risk of seeing an editor rejecting from desk an interesting paper becomes negligible. Under desk rejection, the set of feasible equilibria would be restricted to the sole separating equilibrium.

Conclusion

This paper studies the various equilibria that could result from a publishing game under an *impartial selection process*. It states that the rising pressure on researchers to publish in refereed journals may lead to multiple equilibria with a possibility of congestion of the journals' editorial process.

As long as researchers stay confident about the efficiency of the editors screening process, self-selection prevents authors of low quality papers to submit their work to refereed journals. These journals then receive only high quality papers and are able to publish only influential papers. However, when the reward of a refereed publication increases, the incentive to submit papers to academic journals could lead authors of low quality papers to take their chance in the refereeing process. In this case, some congestion in the editorial mechanism may occur and the accuracy of the selection process will be challenged. As bad papers could be accepted in case of congestion while good ones could be rejected, this effect is obviously detrimental to the

quality of academic journals and to the efficiency of the process of knowledge diffusion.

Facing an increase in the number of submissions, editors often try to restrict the refereeing burden by raising the cost of a rejection for the authors. The model shows that this policy efficiently reduces the incentive for authors of medium or low quality papers to submit to refereed journals. However, as the implementation of such a policy reveals the risk of a congestion of the editorial process, the signal it conveys could help researchers to coordinate on the equilibrium with congestion and this finally could present counterproductive effects. Desk rejection appears as a better way to guarantee the occurrence of the separating equilibrium. Unfortunately, this could also lead editors to only accept submissions of known authors, the ones with good reputation, therefore creating a club in which unknown authors will have no chance to publish. These measures, again, might be detrimental to research and journals' quality.

A solution for the reduction of the congestion burden might come from the increase in the number of academic journals (Goel and Faria 2007). As the number of journals follows a long run increasing trend it appears somewhat logical that the pool of top journals follow the same evolution, reducing the monopoly power of top journals. Such an evolution could reduce the number of submissions received by each journal, increase the global pool of good referees (as identified by the editors) and finally increase the feasibility of the efficient separating equilibrium.

In order to keep the analysis tractable, this paper is built on some restrictive assumptions. For instance the model considers that good referees make perfect assessment of the quality of the submitted papers. Low quality papers will be rejected with certainty by efficient referees while good papers will always be accepted. This is obviously a strong assumption that doesn't fit with the empirical literature[16]. Besides, our description of the editors' behaviour receiving a report from a non reliable referee is rather radical. Future work should consider an editor that would correct bad referees' decisions with probabilities that reflect the intrinsic quality of the paper. Moreover, a more realistic model should link the reward of a publication in a refereed journal to the mean quality of the journals' papers. Despite its limitations, the model is interesting as it stresses that a journal impact could be challenged in case of a radical change in authors confidence in its selection process. The fact that an increase in the reward of publications in a top tier journal may challenge the status of this journal raises important questions about the increasing importance of publication incentives in the general management of science.

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[16] Starbuck (2003) underscores that one of the most striking feature of referee reports is their inconsistence (counting "accept"=1, "reject"=-1 and "revise" as 0, the correlation of the reviewers decision is equal to 0.12).

Appendix: Pooling equilibrium

In this equilibrium, each researcher will play the J-strategy. Researchers' beliefs are thus $\lambda = 1, \ l = 1$. For a *g-type* researcher, the expected payoff of a submission is given by*:*

$$E[U^{g} \mid s = R] = W^{j} - (1 - \alpha)(1 - \theta)[W^{j} - W^{b} + c],$$

and the necessary condition for this equilibrium $E[U^{g} \mid s = B] < E[U^{g} \mid s = R]$ implies*:*

$$\left(W^{j} - W^{b}\right) > \frac{(1-\alpha)(1-\theta)}{\left[1-(1-\alpha)(1-\theta)\right]}c \tag{A1}$$

For a *b-type* researcher, the expected payoff of a submission is*:*

$$E[U^{b} \mid s = R] = \left(W^{b} - c\right) + \alpha(1-\theta)[W^{j} - W^{b} + c],$$

and the necessary condition for this equilibrium, $E[U^{b} \mid s = B] < E[U^{b} \mid s = R]$, implies*:*

$$\left[W^{j} - W^{b}\right] > \frac{(1-(1-\theta)\alpha)}{(1-\theta)\alpha}c \tag{A2}$$

Some simple calculus allows checking that condition (A1) is verified under condition (A2), so this last equation is also the necessary condition for this equilibrium. For a low cost *c* or an important difference between the rewards W^{j} and W^{b}, the congestion effect is at its maximum.

17

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