The Pricing of Academic Journals: A Two-Sided Market Perspective*

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Abstract

More and more academic journals adopt an open-access policy, by which articles are accessible free of charge through the Internet, while publication costs are recovered through author fees. We study the efficient pricing of an academic journal from a two-sided market perspective and the consequences of the open access policy on the journal's quality standards. We provide a new rationale for open-access: in the case of a social welfare maximizing journal, open access is optimal since it induces readers to internalize partially the positive externalities they exert on authors through peer recognition. However, we show that if the journal is run by a not-for-profit association that aims at maximizing the utility of its members (or alternatively the impact of the journal), the move to open-access may result in a decrease in quality standards below the socially efficient level.

Keywords: Academic Journals, Open-Access, Reader-Pays, Two-Sided Market, Endogenous Quality.

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1 Introduction

The development of electronic publishing and the dissatisfaction with academic journal price escalations has lead to an increasing support for the open-access model, where authors pay for submitting and/or publishing their articles, while readers can access published articles at no charge through the Internet.[1] According to the Directory of Open-Access Journals' (DOAJ) website (www.doaj.org), there are already (as of April 12, 2006) 2184 open-access journals in all fields, of which 38 in Economics (such as Theoretical Economics, CES Ifo Forum, Economics Bulletin and IMF staff papers) and 25 in Business and Management. The DOAJ considers that author-pays publishing currently represents approximately 5% of the total market for academic journals.[2]

After several private initiatives[3] endorsed open access to academic journals, some public committees[4] have reported on the issue, and recommended open access for articles resulting from publicly funded research. The report of the Science and Technology Committee of the UK House of Commons (2004) gives an overview of many issues related to author-pays publishing.[5] In summary, the main argument in favor of open-access is greater dissemination of research findings[6]. By contrast, the report expresses concerns that an author-pays model may introduce an incentive for authors to publish less because

[1]According to the public library of science (PLoS), an open-access publication is one that meets the following two conditions:

- The authors and copyright holders grant to all users a free, irrevocable, worldwide, perpetual right of access, subject to proper attribution of authorship, and
- A complete version of the work is deposited immediately upon initial publication in at least one open-access on-line repository.

[2]Among major open-access publishing initiatives, one can mention the Public Library of Science (PLoS) and BioMed Central (see McCabe and Snyder, 2004):

- The PLoS is a not-for-profit organization of scientists that seeks to make the world's scientific literature available, on an open-access basis, but after some delay for material published in subscription journals.
- BioMed Central: It lists more than 100 open-access journals covering all areas of biology and medicine.

  Author fees are typically of the order of USD 1500.

[3]In addition to PLoS mentioned before, there were the Budapest open access initiative (2002), the Bethesda statement on open access publishing (2003) and the Berlin declaration on open access to knowledge in the sciences and humanities (2003). See Dewatripont et als. (2006, p.17) for more details.

[4]For instance, UK House of Commons (2004), OECD (2005) and Dewatripont et al. (2006). The last report was commissioned by the European Commission.

[5]A recent report by OECD (2005) makes similar points.

[6]According to the report, "Author-pays publishing would bring the greatest potential increase in access for groups of users that do not habitually subscribe to journals or belong to subscribing institutions." (p. 76)

of problems of affordability[7]. A second type of concern, which is a focus of our paper, is that author fees may induce publishers to accept a higher proportion of articles, which may have negative implications for quality.[8]

This paper builds a model of an academic journal that fulfills a double role of certification and dissemination of knowledge and studies its pricing from a two-sided market perspective. Adopting first a normative perspective, we show that, for an electronic journal,[9] open access is socially optimal, whenever negative subscription prices are infeasible. This is because the marginal cost of providing access to a new reader is zero, while this new reader exerts positive externalities on authors. Then, adopting a positive perspective, we study a not-for profit journal run by an academic association and show that the change from the traditional reader-pays model to the open access model may lead to a decrease in the quality standard and (more surprisingly) in the readership size of the journal. This is because the journal editors only internalize the welfare of their readers (or the impact of the journal).

Our paper builds on two strands of literature. First, it builds on the recent literature on two-sided markets (see for examples Rochet and Tirole, 2002, 2003, 2006, Caillaud and Jullien, 2003, Evans, 2003 and Armstrong 2006). Two-sided markets can be roughly defined as industries where platforms compete to provide interaction services between two (or several) kinds of users. Typical examples are payment cards, software, Internet and media. In such industries, it is vital for platforms to find a price structure that attracts sufficient numbers of users on each side of the market. Our paper has two novel aspects. First, in addition to choosing a price for each side, the platform (i.e. the academic journal) can choose a minimum quality standard. Second, the externality between authors and readers is not always positive: as the number of published articles increases (and hence as the quality standard decreases), the utility that a reader obtains from the platform increases up to a maximum and then decreases.

Second, our paper builds on the literature on the economics of academic journals, that has initially adopted a one-sided perspective, focusing on library subscriptions (McCabe, 2004, and Jeon and Menicucci, 2006). For instance, Jeon and Menicucci (2006) show that

[7] According to the report, "There is some concern that, ..., there are also those who would not be able to afford to publish in them". (p. 78)

[8] "if author-pays publishing were to become the dominant model, there is a risk that some parts of the market would be able to produce journals quickly, at high volume and with reduced quality control and still succeed in terms of profit, if not reputation. Such journals would cater for those academics for whom reputation and impact were less important factors than publication itself." (p. 81)

[9] Open access can also be optimal for a printed journal if externalities between readers and authors exceed the marginal cost of reproduction and distribution.

bundling electronic journals make it difficult for small publishers to sell their journals.[10] To our knowledge, McCabe and Snyder (2004, 2005a and 2005b) are the first papers to study the pricing of academic journals from a two-sided market perspective. McCabe and Snyder (2004) study the efficiency of the academic journals industry under different structures (monopoly vs competition) but in their model all articles have the same quality and hence journals do not provide any certification function. Our model is closer to McCabe and Snyder (2005a,b), where articles are heterogenous in terms of quality and the journal provides certification services. However, our model endogenizes the quality of the journal. While McCabe and Snyder (2005a,b) take it as given (it is determined by the talent of its editors) and ask which journals are likely to become open-access.[11] By contrast, we study how the move from the reader-pays model to open access affects the quality standard and the readership size of not-for-profit journals.[12]

The rest of the article is organized as follows. Section 2 presents our model. Section 3 characterizes the first-best allocation. Section 4 characterizes the second best allocation, defined as the one that maximizes social welfare under the constraint that readers cannot be subsidized. Section 5 studies the policy chosen by a not-for-profit journal under open access and under the reader-pays model. Section 6 performs a comparison among four different outcomes. Section 6.6 considers, as a robustness check, an impact maximizing journal and performs comparative static. Section 7 concludes.

2 The model

We consider a single academic journal, modelled as a platform between a continuum of authors and a continuum of potential readers. The mass of authors is normalized to one. Each author has one article, and privately observes its quality q, measured as the benefit obtained by reading it. The quality of each article is independently drawn from the same distribution, with support $[0, q_{\max}]$. The journal has a perfect refereeing technology: by

[10] Edlin and Rubinfeld (2004) argue that bundling electronic journals can create strategic barriers to entry but do not build a formal model.

[11] More precisely, they study how the level of editorial talent affects the adoption of open access through the choice of a subscription price. They find that open-access is more likely to be chosen by a journal with poor editorial talent since the subscription price chosen by a for-profit journal increases with its editorial talent.

[12] Another difference is that in McCabe and Snyder (2005a,b) author demand is inelastic and quality standard is exogenous: the journal accepts all articles judged good and authors are identical from an ex ante point of view (since each author has the same prior belief about the quality of her article). Therefore, regardless of the objective of the journal, the content of the journal is the same: the author fee is always chosen to induce the submission of all articles and all articles judged good are published. By contrast, in our paper, the quality of published articles is endogenously determined.

incurring a cost γ_R, it can perfectly observe the quality of each submitted article and decide whether to publish it. There is a publication cost γ_P per published article. Since we want to model electronic journals, distributed through the Internet, we assume that the distribution cost is zero. The journal commits to publish all submitted articles of quality $q \geq q_{\min}$, where $q_{\min}$ is the minimum quality standard chosen by the journal. In addition, the journal chooses its pricing policy. It charges p_S to all submitted articles, an additional p_P to all published articles and a subscription fee p_R to each reader.

Readers cannot observe the quality of an article before reading it but observe its quality after reading it. The mass of readers is normalized to one. We assume that an article's quality cannot be verified ex post by a third party and therefore the journal's pricing scheme cannot be conditioned on realized quality[13].

All readers obtain the same benefit q after reading an article of quality q but differ in their "reading cost" c, which is independently drawn from a distribution with support included in $[0, \infty)$. When an article of quality q is published by the journal, the total (that is, monetary and non-monetary) benefit that the author obtains is given by

$$u + \alpha q n_R,$$

where $u(> 0)$ and $\alpha(> 0)$ are constants and n_R represents the number of readers subscribed to the journal. u is a fixed component: it only depends on whether or not an author's article is published in the journal. For instance, if a tenure decision depends solely on the number of articles published in particular journals, a tenure-track professor derives some utility from publishing her article in those journals, this independently of the quality of the article.[14] By contrast, $\alpha q n_R$ is a variable composent: it depends on the quality of the article. We interpret $q n_R$ as the impact of the article, measured for example by the number of subsequent citations. The constant α measures the strength of the relation between publication impact and authors' utility.

The timing of the game is as follows:

1. The journal announces its editorial policy: $(q_{\min}, p_S, p_P, p_R)$.

2. Authors decide whether or not to submit their articles to the journal.

3. The journal referees all submitted articles and accepts or rejects each of them.

[13] McCabe and Snyder (2005a) assume it as well. It can be justified by the fact that a Court cannot perfectly verify the quality of scientific articles.

[14] u can also represent recognition from non-peers who do not read the journal. For instance, if a scientist publishes an article in Science or Nature, even those who are not able to understand the article will think that she made an important discovery and accordingly will give her their recognition.

4. Readers decide whether or not to buy the journal.

Since both the author and the journal perfectly observe the quality q of a submitted article, the author perfectly knows whether or not her article will be accepted. Therefore, if $q < q_{\min}$ and $p_S > 0$, she will not submit the article. By contrast, if $q > q_{\min}$, the article will be accepted and she will have to pay $p_A \equiv p_S + p_P$. This implies an indeterminacy between p_S and p_P: only p_A matters. The fact that only articles of quality superior to $q_{\min}$ are submitted in our model[15] also implies that what matters for the journal is only the sum $\gamma_P + \gamma_R$, not its composition. Let $\gamma \equiv \gamma_P + \gamma_R$. We assume $\gamma > u$, implying that even when the reading cost is zero, publishing the lowest quality article (i.e. the one with $q = 0$) is not socially optimal.

Each potential reader decides whether to read the journal, based on his expectation of the quality of published articles and on his (unit) cost of reading c. If the n_A best articles are published, the net utility of a reader of cost c is:

$$U_R = n_A[Q^a(n_A) - c] - p_R,$$

where $Q^a(n_A)$ is the (anticipated) average quality of the articles published in the journal. This average quality can be inferred perfectly from the minimum quality standard $q_{\min}$ announced by the journal. Indeed, let us denote by $q(n_A)$ the n_A-th quantile of the distribution of articles' qualities (ranked by decreasing quality: $q(\cdot)$ is thus decreasing). This distribution is supposed to be common knowledge. We have by definition:

$$\Pr(q \geq q(n_A)) = n_A, \tag{1}$$

$$Q^a(n_A) = \frac{\int_0^{n_A} q(x)dx}{n_A}, \tag{2}$$

while

$$q_{\min} = q(n_A). \tag{3}$$

Similarly the number n_R of readers can be perfectly anticipated by authors, since the distribution of readers' costs is also supposed to be common knowledge. Let $c(n_R)$ denote the n_R-th quantile of the cost distribution (ranked by increasing cost: $c(\cdot)$ is thus increasing). We have by definition:

$$\Pr(c \leq c(n_R)) = n_R. \tag{4}$$

Moreover the utility of the marginal reader is zero, and thus:

$$n_A[Q^a(n_A) - c(n_R)] = p_R. \tag{5}$$

[15]We assume however that the journal commits to effectively refereeing all submitted articles.

Thus knowing $q_{\min}$ and p_R (and the distributions of costs and qualities) each author can infer the number n_A of published articles, the average quality $Q^a(n_A)$ of these published articles, and thus by (5) the number of readers. Since we consider a not-for-profit journal we assume that the net utility of the marginal author is strictly positive:[16]

$$u + \alpha n_R q(n_A) > p_A. \tag{6}$$

In particular, we will assume that the marginal author's benefit from publication is larger than γ. This implies that all articles with quality $q \geq q(n_A)$ will be effectively submitted (and published) in the journal.

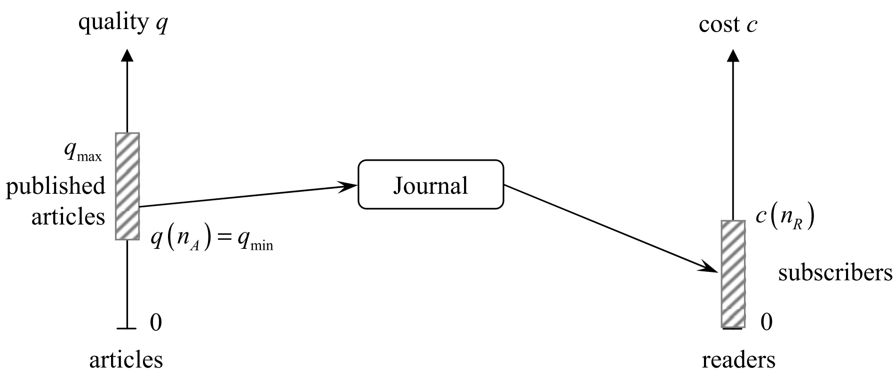

Figure 1: The journal as a platform.

3 The first-best allocation

In this section, we derive the first-best outcome, that would be implemented by a social planner who could choose who reads the journal and which articles are published. Obviously, if there are n_R readers and n_A articles published, efficiency requires that these are the readers with the lowest costs ($c \leq c(n_R)$) and the articles with the highest qualities ($q \geq q(n_A)$). Social welfare, denoted by $W(n_A, n_R)$ is then given by:

$$W(n_A, n_R) \equiv (1+\alpha) n_R \int_0^{n_A} q(x)dx - n_A (\gamma - u) - n_A \int_0^{n_R} c(y)dy. \tag{7}$$

[16]By contrast, a for-profit journal would always select $p_A = p_A^{\max} \equiv u + \alpha n_R q(n_A)$. In this case authors might be rationed by price instead of quality. The Science and Technology committee of the UK House of Commons (2004) discusses this issue: "There is some concern that, just as currently there are people who cannot afford to pay to read scientific journals, there are also those who would not be able to afford to publish in them. (p. 78) ... The variation in the ability of authors to pay to publish is an important factor in any consideration of the author-pays model. (p. 80) ... We recommend that the Research Councils each establish a fund to which their funded researchers can apply should they wish to publish their articles using the author-pays model". (p. 79)

In formula (7), the first term represents the sum of the authors' variable benefit and the readers' benefit when the n_A best articles are published and read by the n_R most efficient readers, the second term represents the net cost of publishing the journal and the last term represents the aggregate cost of reading the journal.

We assume that the parameters are such that the maximum of W is interior: the proportion of published articles is strictly between 0 and 1. Then, from the first order condition with respect to n_A, we have:

$$(1+\alpha)n_R q(n_A) = (\gamma - u) + \int_0^{n_R} c(y)dy. \tag{8}$$

Given that the n_R readers with $c \leq c(n_R)$ read the journal, condition (8) means that the optimal number of articles published, n_A, is determined by equalizing the social marginal benefit from publishing an article of quality $q(n_A)$ to its social marginal cost. The social marginal benefit is equal to $(1+\alpha)n_R q(n_A)$ since when an article of quality $q(n_A)$ is read by some reader, the author derives utility $\alpha q(n_A)$ and the reader derives utility $q(n_A)$. The social marginal cost is equal to the sum of the net cost of publishing an article $(\gamma - u)$ and the aggregate cost of reading an article $\int_0^{n_R} c(y)dy$.

This can be rewritten as:

$$(1+\alpha)q(n_A) = \frac{\gamma - u}{n_R} + C^a(n_R), \tag{9}$$

where

$$C^a(n_R) = \frac{\int_0^{n_R} c(y)dy}{n_R}$$

denotes the average cost of readers.

From the first order condition with respect to n_R, we have:

$$(1+\alpha)\int_0^{n_A} q(x)dx = n_A c(n_R). \tag{10}$$

Given that the n_A articles with quality $q \geq q(n_A)$ are published by the journal, condition (10) means that the optimal number of readers is determined by equalizing the social benefit $(1+\alpha)\int_0^{n_A} q(x)dx$ from having one additional reader to the total cost of reading $n_A c(n_R)$ incurred by this marginal reader. (10) is equivalent to

$$(1+\alpha)Q^a(n_A) = c(n_R), \tag{11}$$

where $Q^a(n_A) \equiv \int_0^{n_A} q(x)dx/n_A$ represents the average quality of the articles published in the journal. Therefore, condition (11) implies that for the marginal reader, the average utility from reading an article of the journal is lower than her cost of reading it (i.e. $Q^a(n_A) < c(n_R)$). Thus, as we shall see below, the marginal reader should be subsidized. This is because she generates positive externalities on authors by reading their articles. Let $\left(n_A^{FB}, n_R^{FB}\right)$ denote the first-best allocation, characterized by (9) and (11).

We now study the minimum quality standard $q_{\min}^{FB}$ and the prices $\left(p_A^{FB}, p_R^{FB}\right)$ that implement the first-best outcome $\left(n_A^{FB}, n_R^{FB}\right)$ when the social planner cannot fully control readers and authors, and has to satisfy the participation constraints for both of them. Obviously, $q_{\min}^{FB}$ must be equal to $q(n_A^{FB})$. Given n_R, let $U_A(n_A : n_R)$ denote the utility that the n_Ath author derives from publishing her article in the journal. We have:

$$U_A(n_A : n_R) = \alpha q(n_A) n_R + u - p_A. \tag{12}$$

In order to induce the submission of all articles of quality superior to $q(n_A^{FB})$, the following constraint should be satisfied:

$$(PC_A)\ U_A(n_A^{FB} : n_R^{FB}) = \alpha q(n_A^{FB}) n_R^{FB} + u - p_A \geq 0;$$

which is equivalent to

$$p_A \leq \alpha q(n_A^{FB}) n_R^{FB} + u \equiv p_A^{\max}.$$

Since $U_A(\cdot)$ strictly decreases with n_A, if (PC_A) is satisfied, the participation constraint is satisfied for all authors with $q \geq q(n_A^{FB})$.

Given n_A, let $U_R(n_R : n_A)$ denote the utility that the n_Rth reader derives from subscribing to (and reading) the journal. We have:

$$U_R(n_R : n_A) = \left[Q^a(n_A) - c(n_R)\right] n_A - p_R. \tag{13}$$

In order to align each reader's incentive to subscribe to the journal (and read it) with the social incentive (i.e. in order to induce only those with $c \leq c(n_R^{FB})$ to subscribe to the journal), the following incentive constraint[17] has to be satisfied for the marginal reader:

$$(IC_R)\ U_R(n_R^{FB} : n_A^{FB}) = \left[Q^a(n_A^{FB}) - c(n_R^{FB})\right] n_A^{FB} - p_R = 0,$$

which is equivalent to

$$p_R = \left[Q^a(n_A^{FB}) - c(n_R^{FB})\right] n_A^{FB} \equiv p_R^{FB}.$$

Since $U_R(\cdot)$ strictly decreases with n_R, then if (IC_R) is satisfied, the participation constraint is satisfied for the readers with $c \leq c(n_R^{FB})$ while it is violated for those with $c > c(n_R^{FB})$. From (11), we have

$$p_R^{FB} = -\alpha Q^a(n_A^{FB}) n_A^{FB} < 0. \tag{14}$$

[17] We call it an incentive constraint instead of calling it a participation constraint since a participation constraint is usually defined by an inequality.

Therefore p_R^{FB} must be strictly negative. By contrast, p_A^{FB} can be strictly positive: this is because an author derives a strictly positive utility from publishing her article in the journal but incurs no submission cost. This implies that charging a positive price can induce the submission of all articles of quality higher than $q(n_A^{FB})$. In fact, any $p_A \leq p_A^{\max}$ achieves it. By contrast, each reader must incur a cost of reading the journal. Since reading generates positive externalities to the authors, in order to induce readers to internalize these externalities, it is optimal to subsidize reading by charging a strictly negative price. Summarizing, we have:

Proposition 1 *(First-best) (i) The first-best allocation* $\left(n_A^{FB}, n_R^{FB}\right)$ *is characterized by:*

$$(1+\alpha)q(n_A) = \frac{\gamma - u}{n_R} + C^a(n_R),$$

$$(1+\alpha)Q^a(n_A) = c(n_R).$$

(ii) To implement the first-best allocation, the social planner has to choose a minimum quality standard equal to $q_{\min}^{FB} \equiv q(n_A^{FB})$ *and prices* $\left(p_A^{FB}, p_R^{FB}\right)$ *satisfying*

$$p_A^{FB} \leq \alpha q(n_A^{FB})n_R^{FB} + u \equiv p_A^{\max};\ p_R^{FB} = -\alpha Q^a(n_A^{FB})n_A^{FB}\,(<0)\,.$$

Therefore, the subscription price must be strictly negative.

4 The second-best allocation

In the previous analysis of the first-best allocation we have made the implausible assumption that the social planner could induce a marginal reader of type $c(n_R^{FB})$ to read the journal by subsidizing it, i.e. by charging a negative subscription price. However, charging a negative subscription price would not, in practice, necessarily induce the marginal reader to read the journal. This is because it is hard to monitor whether or not someone effectively reads the journal. Consequently, a negative subscription price would induce fake readers who have no or very weak interest in reading the journal to subscribe to it only to obtain the subsidy.[18] Therefore, we consider here the second-best outcome in which the social planner is constrained to charge a positive subscription price ($p_R \geq 0$).

Given p_R, the marginal reader is determined by

$$U_R(n_R : n_A) = \int_0^{n_A} q(x)dx - c(n_R)n_A - p_R = 0.$$

[18] By contrast, charging a negative author fee could be feasible since it would be paid upon acceptance of an article and the number of articles of quality superior to a given quality standard is limited.

Therefore, requiring $p_R \geq 0$ is equivalent to requiring

$$c(n_R)n_A \leq \int_0^{n_A} q(x)dx. \tag{15}$$

Hence, in the second best outcome, the social planner maximizes $W(n_A, n_R)$ subject to (15). Again we assume that the parameters are such that the (second-best) optimum is interior: the proportion of published articles is strictly between 0 and 1. Define $L^{SB} = W - \lambda_1 \left[c(n_R)n_A - \int_0^{n_A} q(x)dx\right]$ where $\lambda_1(\geq 0)$ represents the Lagrange multiplier associated with (15). The first-order conditions with respect to n_A and n_R are:

$$(1+\alpha)n_R q(n_A) = (\gamma - u) + \int_0^{n_R} c(y)dy + \lambda_1 \left[c(n_R) - q(n_A)\right]; \tag{16}$$

$$(1+\alpha)\int_0^{n_A} q(x)dx = n_A c(n_R) + \lambda_1 c'(n_R)n_A. \tag{17}$$

Using the fact that (15) binds, we find from (17) that

$$\lambda_1 = \frac{\alpha c(n_R)}{c'(n_R)} > 0.$$

λ_1 represents the marginal increase in social welfare that would occur if the social planner could subsidize readers by a small amount. Inserting $\lambda_1 = \frac{\alpha c(n_R)}{c'(n_R)}$ into (16) gives

$$(1+\alpha)n_R q(n_A) = (\gamma - u) + \int_0^{n_R} c(y)dy + \frac{\alpha c(n_R)}{c'(n_R)}\left[c(n_R) - q(n_A)\right] \tag{18}$$

The fact that (15) binds implies that

$$c(n_R) = Q^a(n_A). \tag{19}$$

In other words, the marginal reader's reading cost is equal to the average quality of the articles published in journal. This, together with $Q^a(n_A) > q(n_A)$ implies that when we compare (8) with (16), the social marginal cost of publishing one more article is larger in the second-best allocation than in the first-best (this is because the additional term $\lambda_1 \left[c(n_R) - q(n_A)\right]$ is positive). Similarly, comparing (10) with (17) shows that the social marginal cost of having one more reader is larger in the second-best than in the first-best. Let $\left(n_A^{SB}, n_R^{SB}\right)$ denote the second-best allocation, which is characterized by (18) and (19). The previous arguments imply that $n_A^{FB} > n_A^{SB}$ and $n_R^{FB} > n_R^{SB}$, at least if W is quasi concave. These inequalities will be established formerly in Section 6, in the case of iso-elastic distribution functions.

Let $\left(p_A^{SB}, p_R^{SB}\right)$ denote a price vector implementing $\left(n_A^{SB}, n_R^{SB}\right)$ when the social planner chooses the quality standard $q^{SB} \equiv q(n_A^{SB})$. Since (15) binds, we have $p_R^{SB} = 0$. Therefore, open-access is second-best optimal. p_A^{SB} has to satisfy the participation constraint of the marginal author, implying :

$$p_A^{SB} \leq \alpha q(n_A^{SB}) n_R^{SB} + u.$$

Proposition 2 *(Second-best) When a negative subscription price is not feasible;*

(i) Open-access is socially optimal; the optimal subscription price p_R^{SB} is zero.

(ii) The second-best allocation $\left(n_A^{SB}, n_R^{SB}\right)$ is characterized by (18) and (19). In particular, $Q^a(n_A^{SB}) = c(n_R^{SB})$ holds.

(iii) If W is quasi-concave in (n_A, n_R) then $n_A^{SB} < n_A^{FB}$ and $n_R^{SB} < n_R^{FB}$.

Proposition 2 gives a rationale for open-access: since internalizing cross-externalities from readers to authors would require a negative subscription price that is not feasible, it is optimal to charge a zero subscription price. This reduces the number of readers with respect to the first-best allocation, which in turn reduces the net social benefit from publishing an article. Therefore the minimum quality standard is higher in the second-best allocation than in the first-best. Note that the second-best allocation coincides with the Ramsey optimum: this is because the budget constraint of authors is not binding.

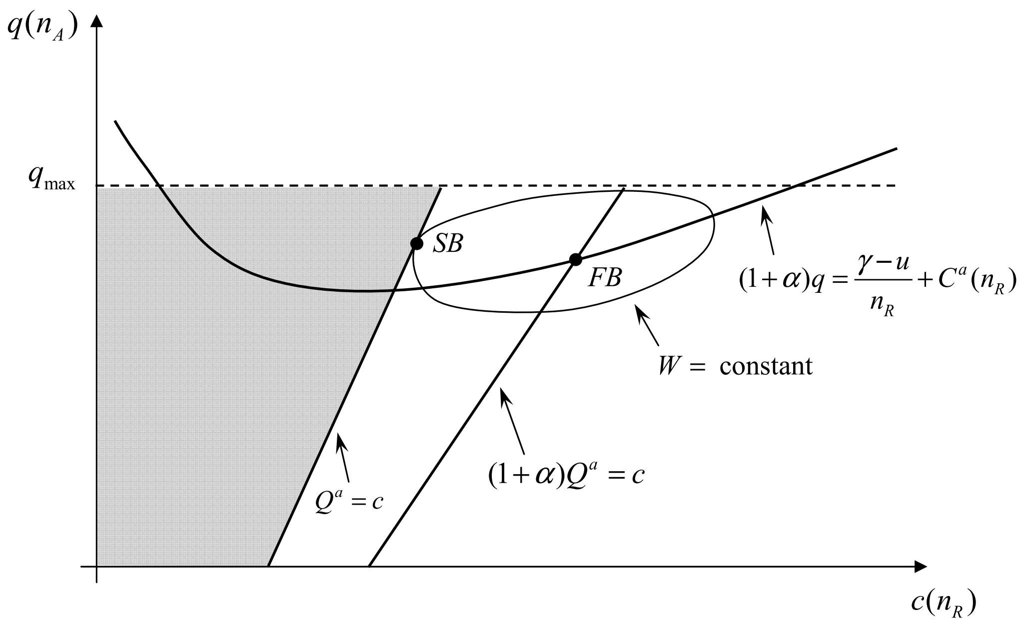

Figure 2: The first-best (FB) and the second-best (SB) allocations.
The shaded area corresponds to the region $p_R \geq 0$ (non negative reader price).

5 Positive analysis

In this section, we adopt a positive viewpoint, and analyze the consequences of the move from reader-pays to open access for a not-for-profit journal run by an academic association. If the objective of the association were to maximize social welfare, this move would lead to the (second best) social optimum (see Proposition 2(i)). However the association is likely to pursue its own objective. We consider two possibilities for the objective function of the association: the total utility of the readers (in this section) or the impact of the journal (in Section 7). Our main result, that open-access is likely to lead to a decrease in the quality of academic journals, holds for both objective functions. We start (in Section 5.1) by explaining the basic intuition behind this result, and then characterize formally the outcomes under Reader-Pays (RP) and Open Access (OA).

5.1 The basic intuition

Recall that the readership of the journal is determined by the indifference of the marginal reader:

$$U(n_R : n_A) \equiv [Q^a(n_A) - c(n_R)]\, n_A - p_R = 0.$$

In the reader-pays model, the author fee is zero, and the budget balance condition of the journal is

$$p_R n_R \geq \gamma n_A.$$

Eliminating p_R between these two conditions, we obtain the inequality characterizing the feasible set of the journal under (RP):

$$Q^a(n_A) \geq c(n_R) + \frac{\gamma}{n_R}. \tag{20}$$

Note that the feasible set under (OA) (where $p_R = 0$) corresponds to the same condition when $\gamma = 0$:

$$Q^a(n_A) \geq c(n_R). \tag{21}$$

Since $\gamma > 0$, we see that for attracting the same number of readers, a RP journal has to offer a higher quality than an OA journal. This is the basic intuition behind our main result: the RP model imposes more discipline on quality choice.

Figure 3 below represents the two feasible sets and the indifference curves of the association. Under fairly general conditions the optimal choice of the association will entail higher quality (and possibly larger readership) under RP than under OA.

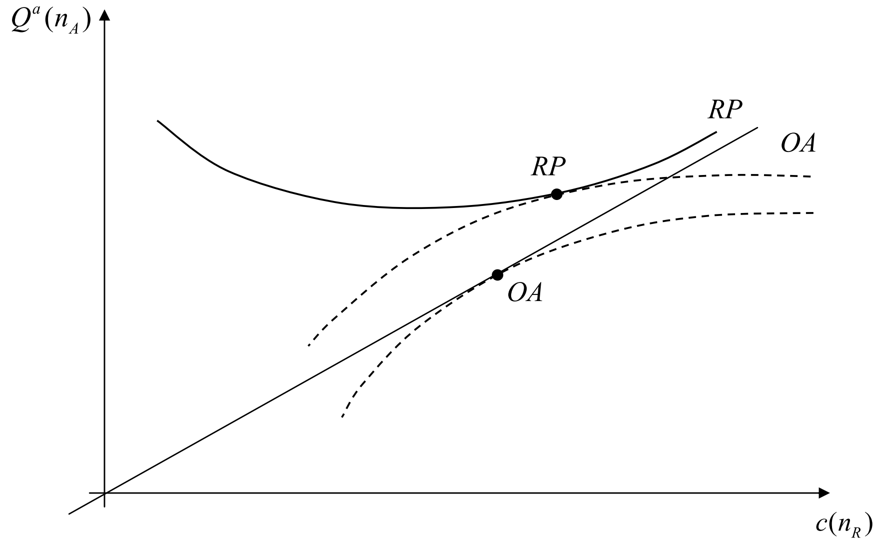

Figure 3: The reader-pays (RP) and the open-access (OA) allocations.
The dashed lines correspond to the indifference curves of the association.

Of course, Figure 3 does not imply that OA always leads to a suboptimal level of quality. In fact, as we already noted, OA is indeed second best optimal when the association maximizes social welfare. This is why we now characterize formally the outcomes RP and OA, in order to compare them with the first best and second best outcomes. In this section, we consider that the association's objective is to maximise the sum of the readers' utilities[19] given by:

$$TUR = \int_0^{n_R} \{[Q^a(n_A) - c(y)]\, n_A - p_R\}\, dy, \tag{22}$$

where TUR means total utility of readers. Since n_R and p_R have to satisfy

$$U_R(n_R : n_A) = [Q^a(n_A) - c(n_R)]\, n_A - p_R = 0,$$

we can replace p_R by $[Q^a(n_A) - c(n_R)]\, n_A$ in (22). We find:

$$TUR\,(n_A, n_R) \equiv n_A \int_0^{n_R} [c(n_R) - c(y)]\, dy.$$

[19]In a more general framework, the association would internalize some fraction of authors' utilities as well since some members (possibly the most influential ones) are also authors. Our formulation here captures in a simple way the bias in the objective of the association toward the readers, as compared with that of the social planner.

5.2 Open-access

We now consider open-access ($p_R = 0$). This, together with $U_R(n_R : n_A) = 0$ implies:

$$c(n_R)n_A = \int_0^{n_A} q(x)dx. \tag{OA}$$

The association maximizes $TUR(n_A, n_R)$ with respect to (n_A, n_R, p_A) subject to (OA), the budget breaking (BB) constraint:

$$(p_A - \gamma)n_A \geq 0, \tag{BB}$$

and the authors' participation constraint:

$$U_A(n_A : n_R) = \alpha q(n_A)n_R + u - p_A \geq 0. \tag{PC_A}$$

Note that p_A does not affect the objective of the association and, among the prices satisfying (BB), $p_A = \gamma$ relaxes the most (PC_A). In what follows, we study the association's choice of (n_A, n_R) assuming that (PC_A) is slack at $p_A = \gamma$.

Define $L^{OA} = TUR - \lambda_2 \left[c(n_R)n_A - \int_0^{n_A} q(x)dx\right]$ where λ_2 represents the Lagrangian multiplier associated with (OA). Then, the first-order conditions with respect to n_A and n_R are given by:

$$\int_0^{n_R} \left[c(n_R) - c(y)\right] dy = \lambda_2 \left[c(n_R) - q(n_A)\right]; \tag{23}$$

$$n_A n_R c'(n_R) = \lambda_2 n_A c'(n_R). \tag{24}$$

(24) is equivalent to

$$\lambda_2 = n_R > 0. \tag{25}$$

λ_2 represents the marginal increase in TUR that would be achieved if the association could subsidize readers. Since the association does not care about authors' utilities, this does not depend on α. Replacing λ_2 with n_R in (23) gives:

$$q(n_A) = \frac{\int_0^{n_R} c(y)dy}{n_R} (\equiv C^a(n_R)). \tag{26}$$

Let $\left(n_A^{OA}, n_R^{OA}\right)$ denote the association's optimal choice under open-access. It is characterized by (OA) and (26). (OA) means that the average quality is equal to the reading cost of the marginal reader. In a somewhat symmetric fashion, condition (26) means that the average reading cost $C^a(n_R)$ is equal to the quality of the marginal author's article.

Proposition 3 *(not-for-profit and open-access) Consider a not-for-profit journal run by an academic association. Under open-access the allocation $\left(n_A^{OA}, n_R^{OA}\right)$ optimally chosen by the association is characterized by two conditions:*

- *the average quality of the articles published in the journal is equal to the reading cost of the marginal reader, and*
- *the average reading cost is equal to the quality of the marginal author's article.*

5.3 Reader-pays

As we already saw, the feasible set of a readers pay journal is characterized by:

$$c(n_R) + \frac{\gamma}{n_R} \leq Q^a(n_A). \tag{27}$$

The left-hand side of (27) is U-shaped in n_R. If its minimum is higher than the maximum quality $q_{\max}$, the feasible set is empty. We have therefore to assume that $q_{\max}$ is large enough to avoid this problem. In this case, for a given n_A, there may be two values of n_R that satisfy (27) with an equality: it is always optimal to choose the highest.

Therefore, the association maximizes $TUR\,(n_A, n_R)$ with respect to (n_A, n_R) subject to (RP). Define $L^{RP} = TUR - \lambda_3 \left[n_A c(n_R) n_R + \gamma n_A - n_R \int_0^{n_A} q(x)dx\right]$ where λ_3 represents the Lagrangian multiplier associated with (27). Then, the first-order conditions with respect to n_A and n_R are given by:

$$\int_0^{n_R} \left[c(n_R) - c(y)\right] dy = \lambda_3 \left[c(n_R)n_R + \gamma - n_R q(n_A)\right]; \tag{28}$$

$$n_A n_R c'(n_R) = \lambda_3 \left[n_A c(n_R) + n_A c'(n_R) n_R - \int_0^{n_A} q(x)dx\right]. \tag{29}$$

Since (27) is binding at the optimum, we have

$$c(n_R)n_R + \gamma = n_R Q^a(n_A). \tag{RP}$$

Inserting (RP) into (28) gives:

$$\lambda_3 = \frac{c(n_R) - C^a(n_R)}{Q^a(n_A) - q(n_A)} > 0. \tag{30}$$

λ_3 represents the marginal increase in TUR if the association's budget constraint is relaxed. When its budget constraint is relaxed, the association can charge a lower subscription price and thereby increase TUR. Inserting (30) into (29) and dividing by n_A gives

$$n_R c'(n_R) = \frac{c(n_R) - C^a(n_R)}{Q^a(n_A) - q(n_A)} \left[c(n_R) + n_R c'(n_R) - Q^a(n_A)\right]. \tag{31}$$

Let $\left(n_A^{RP}, n_R^{RP}\right)$ denote the association's optimal choice under reader-pays model. It is characterized by (RP) and (31).

Proposition 4 *(not-for-profit and reader-pays) Consider a not-for-profit journal run by an association. Under reader-pays, the allocation chosen by the association* $\left(n_A^{RP}, n_R^{RP}\right)$ *is characterized by* (RP) *and (31).*

6 Comparative statics analysis

In this section, we compare four scenarios (first-best, second-best, not-for-profit journal with open-access, not-for-profit journal with reader-pays) in terms of average quality of the articles published in the journal and number of readers. To facilitate the comparison, we choose a particular specification, that we call "iso-elastic":[20]

$$q(n_A) = q_{\max}\left[1 - (n_A)^{\varepsilon_q}\right] \quad \text{and} \quad c(n_R) = (n_R)^{\varepsilon_c}.$$

In our iso-elastic specification we have:

$$Q^a(n_A) = \frac{\varepsilon_q q_{\max} + q(n_A)}{1 + \varepsilon_q}$$

or equivalently:

$$q(n_A) = (1 + \varepsilon_q)Q^a(n_A) - \varepsilon_q q_{\max}.$$

6.1 The first-best allocation

The first-best allocation is characterized by two conditions:

$$(1 + \alpha)q(n_A) = \frac{\gamma - u}{n_R} + C^a(n_R), \tag{9}$$

and

$$(1 + \alpha)\int_0^{n_A} q(x)dx = n_A c(n_R). \tag{10}$$

Condition (9), expressed in terms of (q, c) leads to:

$$(1 + \alpha)q = \frac{\gamma - u}{c^{1/\varepsilon_c}} + \frac{c}{1 + \varepsilon_c}. \tag{32}$$

Condition (10), expressed in terms of the same variables leads to:

$$(1 + \alpha)\left[\varepsilon_q q_{\max} + q\right] = (1 + \varepsilon_q)c. \tag{33}$$

[20]The specification $q(n_A) = K n_A^{-\varepsilon q}$ would not work, since it would imply $q(0) = +\infty$, and hence unbounded article qualities.

Substracting (32) from (33) leads to:

$$\left(\varepsilon_q + \frac{\varepsilon_c}{1+\varepsilon_c}\right) c - \frac{\gamma - u}{c^{1/\varepsilon_c}} = (1+\alpha)\varepsilon_q q_{\max}. \tag{34}$$

Let $\Phi^{FB}(c) \equiv \left(\varepsilon_q + \frac{\varepsilon_c}{1+\varepsilon_c}\right) c - \frac{\gamma-u}{c^{1/\varepsilon_c}}$. Since $\Phi^{FB}(c)$ increases from $\Phi^{FB}(0) = -\infty$ to $\Phi^{FB}(+\infty) = +\infty$, there is a unique solution to (34), denoted $c^{FB} \equiv c(n_R^{FB})$. Replacing c by $(1+\alpha)Q^a$ (this results from (11)) into (34) and dividing (34) by $(1+\alpha)$ gives:

$$\left(\varepsilon_q + \frac{\varepsilon_c}{1+\varepsilon_c}\right) Q^a - \frac{\gamma - u}{(1+\alpha)^{1+1/\varepsilon_c}(Q^a)^{1/\varepsilon_c}} = \varepsilon_q q_{\max}. \tag{35}$$

$Q^{aFB} \equiv Q^a(n_A^{FB})$ is the unique solution of (35).

From (34) and (35), as $\gamma - u$ increases, Q^{aFB} increases and c^{FB} increases. In other words, as the net publication cost increases, it is optimal to increase the quality standard, and to expand readership. From (34) and (35), we also find that as α increases, Q^{aFB} decreases and c^{FB} increases. In other words, as the benefit that authors obtain from peer recognition increases, it is optimal to publish more articles. Since a large α also means that readers exert stronger externalities on authors, it is also optimal to increase the readership size.

6.2 The second-best allocation

It is characterized by two conditions:

$$(1+\alpha)n_R q(n_A) = (\gamma - u) + \int_0^{n_R} c(y)dy + \lambda_1 \left[c(n_R) - q(n_A)\right] \tag{16}$$

and

$$c(n_R) = Q^a(n_A). \tag{19}$$

After replacing $\lambda_1 = \frac{\alpha n_R}{\varepsilon_c}$ into (16) and expressing it in terms of (q, c), we have:

$$(1+\alpha+\frac{\alpha}{\varepsilon_c})q = \frac{\gamma-u}{c^{1/\varepsilon_c}} + c\frac{1+\alpha+\frac{\alpha}{\varepsilon_c}}{1+\varepsilon_c}. \tag{36}$$

From $q = (1+\varepsilon_q)Q^a - \varepsilon_q q_{\max} = (1+\varepsilon_q)c - \varepsilon_q q_{\max}$ (the latter equality results from (19)), condition (36) becomes:

$$\left(\varepsilon_q + \frac{\varepsilon_c}{1+\varepsilon_c}\right) c - \frac{\gamma - u}{(1+\alpha+\frac{\alpha}{\varepsilon_c})c^{1/\varepsilon_c}} = \varepsilon_q q_{\max}. \tag{37}$$

$c^{SB}\left(\equiv c(n_R^{SB})\right)$ is a unique solution of (37). Furthermore, we have $c^{SB} = Q^{aSB} \equiv Q^a(n_A^{SB})$. When we replace c with Q^a in (37) and compare it with (35), from $(1+\alpha)^{1+1/\varepsilon_c} > (1+\alpha+\frac{\alpha}{\varepsilon_c})$, we find

$$Q^{aSB} > Q^{aFB}.$$

From comparing (37) with (34), we find:

$$c^{SB} < c^{FB}.$$

The two inequalities are equivalent to

$$n_A^{FB} > n_A^{SB} \text{ and } n_R^{FB} > n_R^{SB}.$$

6.3 Open-access versus readers-pay

The allocation chosen by a not-for-profit journal under open-access is characterized by two conditions:

$$(OA) \quad c(n_R)n_A = \int_0^{n_A} q(x)dx.$$

and

$$q(n_A) = \frac{\int_0^{n_R} c(y)dy}{n_R}(\equiv C^a(n_R)). \tag{26}$$

From $q = (1+\varepsilon_q)Q^a - \varepsilon_q q_{\max}$, (26) becomes

$$(1+\varepsilon_q)Q^a - \varepsilon_q q_{\max} = \frac{c}{1+\varepsilon_c} \tag{38}$$

Replacing c with Q^a in (38) gives Q^{aOA}

$$\left(\varepsilon_q + \frac{\varepsilon_c}{1+\varepsilon_c}\right)Q^{aOA} = \varepsilon_q q_{\max}. \tag{39}$$

Similarly the readers-pay allocation is characterized by two conditions:

$$n_A c(n_R)n_R + \gamma n_A = n_R \int_0^{n_A} q(x)dx. \tag{RP}$$

and

$$n_R c'(n_R) = \frac{c(n_R) - C^a(n_R)}{Q^a(n_A) - q(n_A)}\left[c(n_R) + n_R c'(n_R) - Q^a(n_A)\right]. \tag{31}$$

We have $C^a = \frac{1}{1+\varepsilon_c}c$ and (RP) is equivalent to

$$Q^a = c + \frac{\gamma}{c^{1/\varepsilon_c}}. \tag{40}$$

If we express (31) as a function of c, using $C^a = \frac{1}{1+\varepsilon_c} c$ and (40), we get

$$\left(\varepsilon_q + \frac{\varepsilon_c}{1+\varepsilon_c}\right) c - \frac{\gamma(\frac{1}{1+\varepsilon_c} - \varepsilon_q)}{c^{1/\varepsilon_c}} = \varepsilon_q q_{\max}. \tag{41}$$

6.4 Average quality

Let us compare the first-best with the allocation chosen by an open-access association in terms of average quality. Comparing (35) with (39) tells us that

$$Q^{aFB} > Q^{aOA}.$$

We now compare the first-best allocation with the reader-pays outcome, again in terms of average quality. Replacing c with $Q^a - \frac{\gamma}{c^{1/\varepsilon_c}}$ into the first term of (41) gives

$$\begin{aligned}\left(\varepsilon_q + \frac{\varepsilon_c}{1+\varepsilon_c}\right)\left(Q^a - \frac{\gamma}{c^{1/\varepsilon_c}}\right) - \frac{\gamma}{c^{1/\varepsilon_c}}\left(\frac{1}{1+\varepsilon_c} - \varepsilon_q\right) &= \left(\varepsilon_q + \frac{\varepsilon_c}{1+\varepsilon_c}\right) Q^a - \frac{\gamma}{[\tilde{c}(Q^a)]^{1/\varepsilon_c}} \\ &= \varepsilon_q q_{\max}, \end{aligned} \tag{42}$$

where $\tilde{c}(Q^a)$ is the largest c that satisfies (40). This function is defined for

$$Q^a > \min_c \left[c + \frac{\gamma}{c^{1/\varepsilon_c}}\right].$$

We assume that $q_{\max}$ is large enough for this set to be non empty. In this case, Q^{aRP} is determined by (42). $Q^a > \tilde{c}(Q^a)$ implies

$$\left(\varepsilon_q + \frac{\varepsilon_c}{1+\varepsilon_c}\right) Q^a - \frac{\gamma}{(Q^a)^{1/\varepsilon_c}} > \left(\varepsilon_q + \frac{\varepsilon_c}{1+\varepsilon_c}\right) Q^a - \frac{\gamma}{[\tilde{c}(Q^a)]^{1/\varepsilon_c}}, \tag{43}$$

where the left hand side of the inequality strictly increases with Q^a. Let $\widetilde{Q}^a$ denote the solution of

$$\left(\varepsilon_q + \frac{\varepsilon_c}{1+\varepsilon_c}\right) Q^a - \frac{\gamma}{(Q^a)^{1/\varepsilon_c}} = \varepsilon_q q_{\max}. \tag{44}$$

Then, (42) and (43) imply that $\widetilde{Q}^a < Q^{aRP}$. Comparing (44) with (37) (and in the latter condition, we replace c with Q^a) leads to $\widetilde{Q}^a > Q^{aSB}$, which in turn implies $Q^{aRP} > Q^{aSB}$. Since we know that $Q^{aSB} > Q^{aFB}$, we have finally:

$$Q^{aRP} > Q^{aSB} > Q^{aFB} > Q^{aOA}.$$

Note that Q^{aOA} and Q^{aRP} do not depend on the parameters (α, u) that affect authors' benefits. Furthermore, under open-access, γ does not affect the quality choice of the association since there are (by assumption) sufficiently many authors who are willing to pay $p_A = \gamma$ to publish their articles: the participation constraint of authors is not binding. Therefore, as long as the net cost of publication $\gamma - u$ is positive, the association publishes too many articles under open-access: $Q^{aOA} < Q^{aSB}$. Under the reader-pays model, the association has to recover γn_A by charging readers. Hence, an increase in γ increases its quality standard. By contrast, what matters for the social planner is the net cost $\gamma - u$. This, together with the fact that the association does not internalize the authors' benefit, makes the reader-pays association publish too few articles.

The following table compares the determinants of average quality of published articles in the four regimes.

First-Best	$\left(\varepsilon_q + \frac{\varepsilon_c}{1+\varepsilon_c}\right) Q^a - \frac{\gamma - u}{(1+\alpha)^{1+1/\varepsilon_c}(Q^a)^{1/\varepsilon_c}} = \varepsilon_q q_{\max}$
Second-Best	$\left(\varepsilon_q + \frac{\varepsilon_c}{1+\varepsilon_c}\right) Q^a - \frac{\gamma - u}{(1+\alpha+\alpha/\varepsilon_c)(Q^a)^{1/\varepsilon_c}} = \varepsilon_q q_{\max}$
Open-Access	$\left(\varepsilon_q + \frac{\varepsilon_c}{1+\varepsilon_c}\right) Q^a = \varepsilon_q q_{\max}$
Readers-Pay	$\left(\varepsilon_q + \frac{\varepsilon_c}{1+\varepsilon_c}\right) Q^a - \frac{\gamma}{[\tilde{c}(Q^a)]^{1/\varepsilon_c}} = \varepsilon_q q_{\max}$, where $\tilde{c}(Q^a)$ is the largest solution of $Q^a = c + \frac{\gamma}{c^{1/\varepsilon_c}}$.

Table 1: Average Qualities.

6.5 Readership size

We know that $n_R^{FB} > n_R^{SB}$. Furthermore, since the marginal reader is determined by the average quality of articles (i.e. $Q^a = c(n_R)$) under open-access, the fact that the average quality is higher under the second-best than with an open-access association (i.e. $Q^a(n_A^{SB}) > Q^a(n_A^{OA})$) implies that readership size is larger in the former than in the latter (i.e. $c(n_R^{SB}) > c(n_R^{OA})$). Therefore, we have:

$$n_R^{FB} > n_R^{SB} > n_R^{OA}.$$

We now compare the policy of an open-access association with that of a reader-pays association in terms of readership size. For this purpose we need to compare (39) (in which we replace Q^a with c) with (41). The comparison gives

$$c(n_R^{OA}) > c(n_R^{RP}) \text{ if and only if } \varepsilon_q > \frac{1}{1+\varepsilon_c}.$$

If $\varepsilon_q > \frac{1}{1+\varepsilon_c}$ holds, the change from the reader-pays model to the open-access increases the readership size of the journal run by the association, as could have been expected. A rather surprising result holds if $\varepsilon_q < \frac{1}{1+\varepsilon_c}$: in this case open-access reduces, instead of increasing, the readership size. This is because even though readers do not pay for subscription, the average quality of the journal is so low under open-access, that their benefit net of subscription price is higher under the reader-pays model than under open-access.

Summarizing, we have:

Proposition 5 *When $q(n_A) = q_{\max}\left[1 - (n_A)^{\varepsilon_q}\right]$ and $c(n_R) = (n_R)^{\varepsilon_c}$, we have:*

(i) (average quality)

$$Q^a(n_A^{RP}) > Q^a(n_A^{SB}) > Q^a(n_A^{FB}) > Q^a(n_A^{OA}).$$

The association tends to choose too high a quality standard under the reader-pays model and too low a quality standard under open-access.

(ii) (readership size)

(a)

$$n_R^{FB} > n_R^{SB} > n_R^{OA}.$$

(b)

$$n_R^{OA} \gtreqless n_R^{RP} \textit{ if and only if } \varepsilon_q \gtreqless \frac{1}{1+\varepsilon_c}.$$

The change from the reader-pays model to the open-access model increases the readership size of the journal if $\varepsilon_q > \frac{1}{1+\varepsilon_c}$ and reduces it if $\varepsilon_q < \frac{1}{1+\varepsilon_c}$.

The comparison of readership sizes for an open-access and a readers-pay journals is illustrated in Table 2 and Figures 4 and 5.

Open-Access	$\left(\varepsilon_q + \frac{\varepsilon_c}{1+\varepsilon_c}\right) c(n_R) = \varepsilon_q q_{\max}$
Readers-Pay	$\left(\varepsilon_q + \frac{\varepsilon_c}{1+\varepsilon_c}\right) c(n_R) + \frac{\gamma}{n_R}\left(\varepsilon_q - \frac{1}{1+\varepsilon_c}\right) = \varepsilon_q q_{\max}$

Table 2: Readership Sizes.

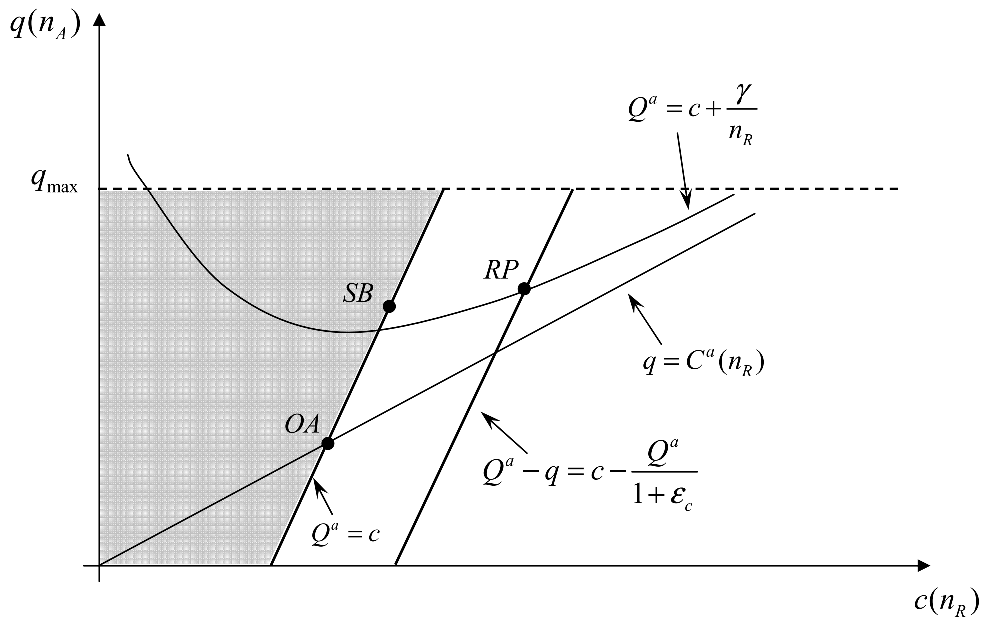

Figure 4: The allocations chosen by a not-for-profit journal when $\varepsilon_q < \frac{1}{1+\varepsilon_c}$ (OA: open-access, RP: readers pay).

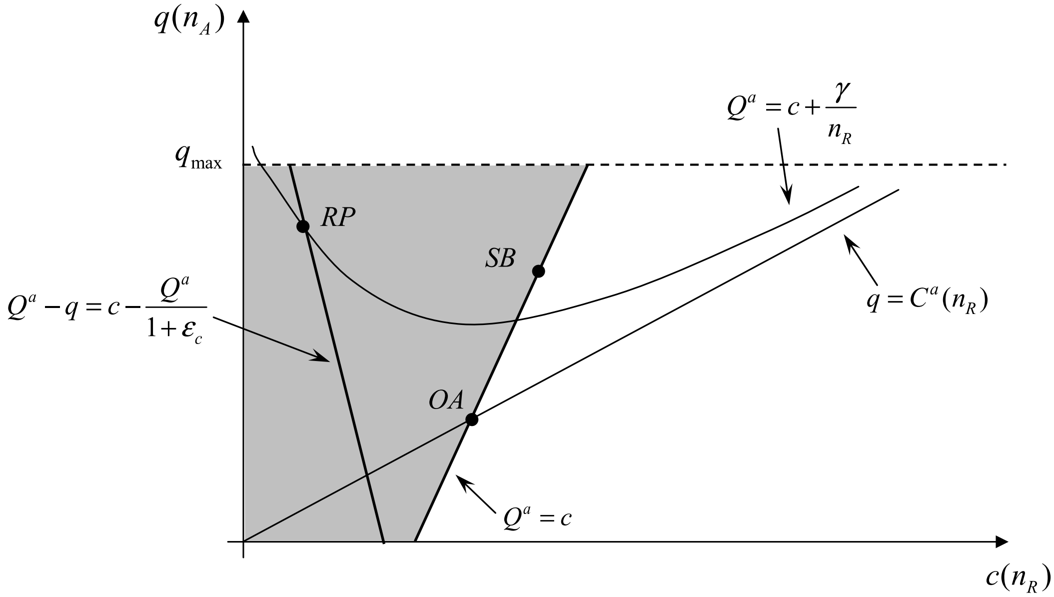

Figure 5: The allocations chosen by a not-for-profit journal when $\varepsilon_q > \frac{1}{1+\varepsilon_c}$ (OA: open-access, RP: readers pay).

6.6 Robustness: Impact-maximizing journal

Maximizing the utility of readers is a reasonable objective for a readers-pay (not for profit) journal, since readers are also the members of the association that controls the journal. However this objective seems less natural for an open-access journal. Thus the move from readers-pay to open-access may be accompanied by a change in objective. To account for this possibility, and as a robustness check, we consider now an alternative objective for the journal. We assume that it endeavours to maximize its impact, defined as the sum of all readers' benefit from reading the journal:

$$IM(n_A, n_R) \equiv n_R \int_0^{n_A} q(y)dy.$$

The association maximizes $IM(n_A, n_R)$ with respect to (n_A, n_R, p_A) subject to (OA), the budget breaking constraint and the authors' participation constraint:

$$(p_A - \gamma)n_A \geq 0; \tag{BB}$$

$$U_A(n_A : n_R) = \alpha q(n_A)n_R + u - p_A \geq 0. \tag{PC_A}$$

Note that p_A does not affect the objective of the association and, among the prices satisfying (BB), $p_A = \gamma$ relaxes the most (PC_A). In what follows, we study the association's choice of (n_A, n_R) assuming that (PC_A) is slack at $p_A = \gamma$.

Define $L^{IM,OA} = IM(n_A, n_R) - \lambda_4 \left[c(n_R)n_A - \int_0^{n_A} q(x)dx \right]$ where λ_4 represents the Lagrangian multiplier associated with (OA). Then, the first-order conditions with respect to n_A and n_R are given by:

$$n_R q(n_A) = \lambda_4 \left[c(n_R) - q(n_A) \right]; \tag{45}$$

$$\int_0^{n_A} q(y)dy = \lambda_4 n_A c'(n_R). \tag{46}$$

(46) is equivalent to

$$\lambda_4 = \frac{\int_0^{n_A} q(y)dy}{n_A c'(n_R)} n > 0. \tag{47}$$

λ_4 represents the marginal increase in the impact that would occur if the association could subsidize readers. Replacing λ_4 in (45) with the expression in (47) gives:

$$n_R q(n_A) n_A c'(n_R) = \int_0^{n_A} q(y)dy \left[c(n_R) - q(n_A) \right]. \tag{48}$$

From the binding (OA), we have $Q^a(n_A) = c(n_R)$. Rearranging (48) by using $Q^a(n_A) = c(n_R)$ gives:

$$q(n_A) = \frac{c(n_R)}{1 + \frac{n_R c'(n_R)}{c(n_R)}}. \tag{49}$$

Therefore, the allocation chosen by the impact-maximizing organization under open access, denoted by $\left(n_A^{IM,OA}, n_R^{IM,OA} \right)$, is characterized by (49) and (OA).

In the iso elastic case, it coincides with the allocation chosen by an open-access journal maximizing the utility of its readers. Indeed condition (26) (marginal quality equals average readers cost) coincides in this case with (49):

$$C^a(n_R) = \frac{1}{n_R} \int_0^{n_R} c(y)dy = \frac{c(n_R)}{1 + \varepsilon_c}.$$

Proposition 6 *(i) Under open access, the allocation chosen by an impact-maximizing journal* $\left(n_A^{IM,OA}, n_R^{IM,OA} \right)$ *is characterized by* (OA) *and (49).*

(ii) In the iso-elastic case, it coincides with the allocation chosen by a journal who maximizes the utility of readers.

Proposition 6 shows the robustness of our main conclusion, at least in the iso-elastic case. Independently of whether the journal maximizes its impact or the utility of its readers, it chooses the same quality standard, which is under optimal. The move to open-access is likely to result in the publication of too many articles from a social welfare viewpoint.

7 Conclusion

We showed that in the case of a social welfare maximizing journal, open access is optimal in the second best world in which the subscription price cannot be negative. The rationale for open access is based mainly on the internalization of the cross externalities that readers exert on authors through peer recognition. We also examined the consequences of a move from the readers-pay model to the open-access model by considering academic journals run by not-for-profit associations. We considered both the reader-controlled association and the impact-maximizing association and found in both cases that this move is likely to lead to a decrease in journals' quality below the socially optimal level. Although we were not able to prove this result in full generality, we have established it for a reasonably large class of distribution functions. The basic intuition behind it is simple: under open access, the association does not internalize the cost of publication (which is covered by authors) while under the reader-pays model, the association internalizes it. As long as those authors are not budget constrained, the association will choose to publish too many articles under open access. Our framework could be used to conduct similar analysis for other objectives of the journal: we could consider a profit-maximizing journal or a not-for-profit journal controlled by authors.

There are other interesting issues to study regarding open access journals. One of them is to know how the change in the pricing model affects competition among journals. There is a "bottleneck argument"[21] that the change from reader-pays to open access would promote competition for the following reason. Once articles are published in journals, each journal is a bottleneck and has a monopoly power on its content; however, when authors submit their articles, journals are substitutes and face competition. We plan to examine this argument by considering competition between for-profit journals within our framework and focusing on how the change of the pricing model affects quality standards of journals.

[21] For instance, see "there are two (non conflicting) theoretical possibilities for increasing price competition in the market: shift price competition to a level where journals are viewed as substitute rather than complement or make researchers and users more price sensitive" Dewatripont et als. (p.67, 2006).

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