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, while publication costs are recovered through author fees. We study the consequences of this open access policy on a journal's quality standard. If the journal's objective was to maximize social welfare, open access would be optimal as long as the positive externalities generated by its diffusion exceed the marginal cost of distribution. However, if the journal has a different objective (such as maximizing readers' payoffs, the impact of the journal or its profit), the move from the traditional reader-pays model to the open-access model may result in a decrease in quality standard 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 led to an increasing support for the open-access model (also called the author-pays 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 February 20, 2008) 3199 open-access journals in all fields, of which 67 in Economics (such as Theoretical Economics, CES Ifo Forum, Economics Bulletin and IMF staff papers) and 55 in Business and Management. Open access 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 public support for experimentation of open access journals. The report of the Science and Technology Committee of the UK House of Commons (House of Commons henceforth, 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

[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]See House of Commons Science and Technology Committee (2004, p.73). Among major open-access publishing initiatives, one can mention the Public Library of Science (PLoS) and BioMed Central:

- The PLoS is a nonprofit organization of scientists and physicians committed to making the world's scientific and medical literature a freely available public resource. The publication fee ranges from USD 1250 to 2500.
- BioMed Central is an independent publishing house committed to providing immediate open access to peer-reviewed biomedical research. Its portfolio of 172 journals includes general titles such as Journal of Biology, alongside specialist journals (e.g. BMC Bioinformatics, Malaria Journal) that focus on particular disciplines. Its average publication fee is USD 1470.

[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 al. (2006, p.17) for more details.

[4]For instance, 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 House of Commons (2004), "Author-pays publishing would bring the greatest potential

expresses concerns that an author-pays model may introduce an incentive for authors to publish less because of problems of affordability[7]. A second type of concern, which is the focus of our paper, is that author fees may induce journal editors 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 viewpoint, we show that, for an electronic journal, open access is socially optimal because the marginal cost of providing access to a new reader is zero. If subsidizing readers (through a negative subscription price) were feasible, it would be even optimal to do so because each new reader exerts positive externalities on the rest of society. An example of these positive externalities is the development of innovations inspired by the ideas contained in the academic articles. This implies that open access can also be optimal for a printed journal (that has a positive cost of dissemination) if the positive externalities exerted by readers exceed the marginal cost of dissemination (reproduction and distribution). Even though authors also exert positive externalities by publishing their articles, there is no need to subsidize authors for submitting articles as long as they get substantial benefits from publication, while the submission cost is negligible.[9]

Then, adopting a positive perspective, we consider both a not-for profit journal and a for-profit journal and study how the change from the traditional reader-pays model to the open access model affects the journal's quality standard. We find that in both cases, but for different reasons, the change can create a decrease in quality below the socially efficient level. We first consider a not-for-profit journal run by an academic association. If the objective of the association were to maximize social welfare, the move to open access would lead to the social optimum. However the association is likely to pursue its own objective. We consider two possibilities for its objective: the total utility of the readers or the impact of the journal. We find that the change may lead to a decrease in the quality standard and

increase in access for groups of users that do not habitually subscribe to journals or belong to subscribing institutions." (p. 76)

[7]According to House of Commons (2004), "There is some concern that, ..., there are also those who would not be able to afford to publish in them". (p. 78)

[8]According to House of Commons (2004), "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]We focus here on the dissemination of academic output (i.e. research articles) and do not model the prior stage where these articles are produced. It is needless to say that subsidizing research (i.e. production of articles) is socially desirable.

thereby (more surprisingly) a reduction in the readership size. The intuition can be given in two steps. First, taking as given the quality standard chosen under the reader-pays model, the move to open access increases the number of readers. Second, after the move, the association will in general increase readers' utility by lowering the quality standard in order to publish more articles. This occurs whenever the quality standard chosen by the association is superior to the average reading cost, which is the case if distributions of authors and readers have constant elasticities. Furthermore, if distributions of authors and readers are elastic enough, this quality degradation can result in reducing the number of readers compared to the level under the reader-pays model. Basically, the reader-pays model imposes more discipline on quality than the open-access model since the former needs to recover publication costs from subscription revenues and therefore attracting the same number of readers requires the former to provide a higher quality than the latter. In addition, we show that under open access, an impact-maximizing journal chooses the same quality standard (and hence the same number of readers) as the one chosen by a journal maximizing readers' utility.

In the case of a for-profit journal, we show that it tends to choose too high a standard under reader-pays model while it can choose too low a standard under open access. Under the reader-pays model, publishing low quality articles that give readers a benefit smaller than their reading cost only reduces the journal's profit. On the contrary, under open access, the journal does not internalize readers' costs of reading as long as they are willing to read the journal. Therefore the journal can have an incentive to publish low quality articles in order to increase its profit from author fees. In summary, in the case of a for-profit journal, quality degradation is caused by the non-internalization of reading costs while in the case of a not-for-profit journal maximizing readers' utility (and hence internalizing reading costs), quality degradation is caused by the non-internalization of publication costs.

Our paper builds on two strands of the literature. First, it builds on the literature on two-sided markets (see for example Rochet and Tirole, 2002, 2003, 2006, Caillaud and Jullien, 2003, Evans, 2003, Armstrong 2006 and Hagiu 2006). Two-sided markets can be roughly defined as industries where platforms 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 from authors to readers is not always positive: as the number of published articles increases (and hence as the quality standard decreases), the net 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 bundling electronic journals makes it difficult for small publishers to sell their journals.[10] To our knowledge, McCabe and Snyder (2005a,b, 2006, 2007) are the first papers to study the pricing of academic journals from a two-sided market perspective. McCabe and Snyder (2006, 2007) study pricing of academic journals industry under different structures (monopoly, duopoly, free entry) but in their model all articles have the same quality and hence journals do not provide any certification function.[11] Our model is closer to McCabe and Snyder (2005a,b) in that they consider a monopoly journal providing certification services when articles are heterogenous in terms of quality. However, there are significant differences. McCabe and Snyder (2005a,b) take the quality standard of the journal as given (it is determined by the talent of its editors) and ask how the quality standard affects the subscription price and thereby the adoption of open access.[12] By contrast, we endogenize the quality standard of the journal and study how the move from the reader-pays model to open access affects the quality standard and the readership size of a journal.[13]

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 reading cannot be subsidized. Section 5 studies the policy chosen by a not-for-profit journal maximizing readers' utility under the reader-pays model and under open access. Section 6 performs a comparison among four different outcomes. Section 7 considers, as robustness checks, a hybrid model (charging both author fee and subscription price), an impact maximizing journal and a for-profit journal. Section 8 concludes.

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

[11]An exception is section 5.4 in McCabe and Snyder (2007) where they consider free entry and quality certification. They obtain specialization result: articles of different qualities are published by different journals.

[12]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.

[13]There are three other differences. First, they do not consider a not-for-profit journal whose objective is different from social welfare. Second, they consider binary support for an article's quality while we consider continuous support. Last, author demand is inelastic in their model while it is elastic in our model. More precisely, since, in their model, every author has the same prior belief about the quality of her article, the author fee is always chosen to induce the submission of all articles. By contrast, in our paper, each author knows the quality of her article and hence submits her paper only if it meets the quality standard.

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,[14] which embodies "ideas" that may be useful to readers, for example because they allow them to develop innovations. The benefit from each innovation is not fully appropriated by the reader/innovator but also spills over to the rest of society, including to the author herself, through peer recognition.

The only way in which authors and readers can interact is through the academic journal.[15] Three conditions are required for this interaction to occur:

- authors must submit their articles to the journal;
- the journal must referee them and publish only those that meet its quality standard;
- readers must read the published articles.

Thus, in our model, the academic journal plays two crucial roles: it **disseminates** academic production (i.e. articles) and **certifies** the quality of these articles in order to convince readers to read the journal. Since time is costly to readers, they will indeed read the journal only if they anticipate that the average quality of articles is good enough. Symmetrically, the benefit that an author obtains from publication increases with the readership size of the journal. Thus we are in a "chicken and egg" situation, characteristic of two-sided markets,[16] where the platform (here the academic journal) has to attract both sides (here authors and readers) to be successful. However, by contrast with most of the literature on two-sided markets, the platform controls not only the number of interactions but also their quality, through its certification function.

The quality of each article is measured by a number q that is independently drawn from the same distribution, with support $[0, q_{\max}]$. We assume that the quality of an article is privately observed by its author. The journal has a perfect refereeing technology: by incurring a cost γ_R, it can perfectly observe the quality of a submitted article. Since our focus is on electronic journals, distributed through the Internet, we assume that the

[14] Since we focus on the certification/dissemination of academic research, we do not model the prior stage where articles are produced.

[15] This is because we assume that the average quality of the unpublished articles that are directly accessible through Internet is so low that readers prefer to look only at published articles. The academic journal plays thus a fundamental certification role: it filters out "junk" articles.

[16] See for example Caillaud and Jullien (2003), Rochet and Tirole (2003) and Armstrong (2006).

marginal cost of distribution is zero.[17] The journal incurs a publication cost γ_P per published article; it includes the cost of making the first (electronic) copy and any fixed cost of distribution per article (such as the cost of buying capacity to post an article). 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. 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[18].

The mass of readers is also normalized to one. All readers obtain the same expected 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 $[0, \infty)$. Readers' benefit includes not only the increase in their knowledge but also the utility that they obtain from its use (such as production of other scientific articles, patents, commercial applications). As already mentioned, when an article is read, some utility from its potential applications also spills over to the rest of society, including to the author herself. More precisely, 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

$$u + \alpha_A q n_R,$$

where $u(> 0)$ and $\alpha_A(> 0)$ are constants and n_R represents the number of readers. u is a fixed component: it corresponds to the utility from having one article 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.[19] By contrast, $\alpha_A q n_R$ is a variable component: it depends on the quality of the article. We interpret $q n_R$ as the impact of the article, proportional to the number of subsequent citations or to the number of patents that are subsequently based on the article. The constant $\alpha_A(> 0)$ measures the strength of the relation between publication impact and authors' utility.

[17] However our arguments can also be applied to a print journal, provided the marginal cost of printing and distributing copies is not too big.

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

[19] 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.

A similar term $\alpha_S n_R$ with $\alpha_S(> 0)$ represents the benefit that spills over to the rest of society. We denote by $\alpha = \alpha_A + \alpha_S$ the total externality term.

The timing of the game is as follows:

1. The journal announces its editorial policy ($q_{\min}$) and its prices (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.

4. Readers decide whether or not to buy the journal and read the articles.

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 the author fee $p_A(\equiv p_S + p_P)$. 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[20] 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. This assumption captures the certification role of the academic journal: by rejecting articles of low quality, the journal allows readers to concentrate on important articles and avoid proliferation of bad ones.

In summary, when an article is published in the journal, its author gets a fixed utility u while the journal incurs a fixed cost $\gamma(> u)$. When an article of quality q is read by a reader of cost c, the reader gets net utility $(q - c)$, and the rest of society (including the author) gets utility αq.

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.[21] This average quality can be inferred perfectly from the minimum quality standard $q_{\min}$

[20] We assume however that the journal commits to effectively referee all submitted articles.

[21] This formula presumes that the readers who subscribe to the journal read all the articles it contains. It is indeed optimal for them to do so. This comes from two of our assumptions: the cost of reading article is proportional to the number of articles read and articles qualities are indistinguishable a priori. The reading decision is thus all or nothing. Our analysis could be easily extended to the case where partial

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,[22] and thus:

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

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. Figure 1 describes the journal as a platform mediating authors and readers.

reading can be optimal (interior solution) either because reading cost is strictly convex in the number of articles or because the journal signals the quality of the articles by ranking them in decreasing order of quality.

[22] In practice, journals are often subscribed by libraries. Our model is compatible with this situation, provided that the library decides its subscription policy in accord with the interests of the community it represents. Parameter c is then the average cost of readers belonging to the community.

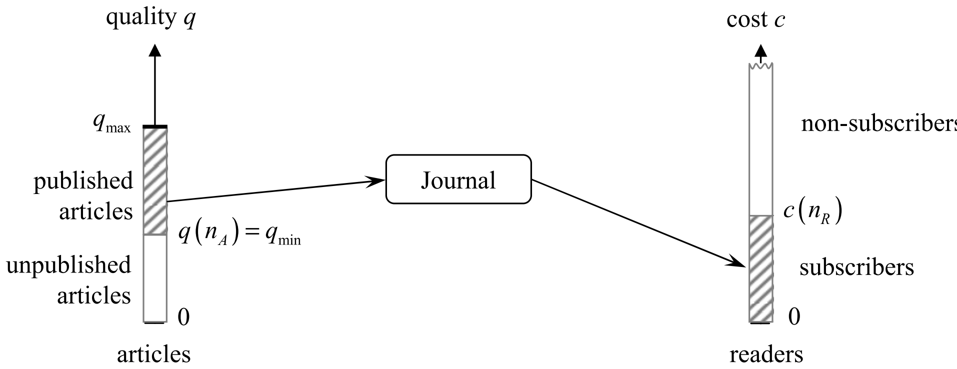

Figure 1: The journal as a platform.

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_A articles published and n_R readers, efficiency requires that these are the articles with the highest qualities ($q \geq q(n_A)$) and the readers with the lowest costs ($c \leq c(n_R)$). Social welfare, denoted by $W(n_A, n_R)$ is then given by:

$$W(n_A, n_R) \equiv (1+\alpha) n_R \int_0^{n_A} q(x)dx - n_A(\gamma - u) - n_A \int_0^{n_R} c(y)dy. \tag{6}$$

In formula (6), the first term represents social benefit (readers + authors + the rest of society) when the n_A best articles are published and read by the n_R most efficient readers, the second term represents the total cost of publishing the journal, minus the total fixed benefit of authors 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:

$$(1+\alpha) n_R q(n_A) = (\gamma - u) + \int_0^{n_R} c(y)dy. \tag{7}$$

Given that the n_R readers with $c \leq c(n_R)$ read the journal, condition (7) 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 a reader, the reader derives utility $q(n_A)$, while the rest of society (including the author) derives utility $\alpha q(n_A)$. 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 $\int_0^{n_R} c(y)dy$. (7) can be rewritten as:

$$(1+\alpha)q(n_A) = \frac{\gamma - u}{n_R} + C^a(n_R), \tag{8}$$

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:

$$(1+\alpha)\int_0^{n_A} q(x)dx = n_A c(n_R). \tag{9}$$

Given that the n_A articles with quality $q \geq q(n_A)$ are published by the journal, condition (9) 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. (9) is equivalent to

$$(1+\alpha)Q^a(n_A) = c(n_R). \tag{10}$$

Since the externality term α is positive, condition (10) 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 the rest of society by increasing the impact of articles and/or the number of innovations derived from them. Let $\left(n_A^{FB}, n_R^{FB}\right)$ denote the first-best allocation, characterized by (8) and (10).

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:

$$U_A(n_A : n_R) = \alpha_A q(n_A) n_R + u - p_A. \tag{11}$$

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

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

which is equivalent to

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

Note that when (PC_A) is satisfied, the participation constraint is also satisfied for all inframarginal authors, for which $q \geq q(n_A^{FB})$.

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:

$$U_R(n_R : n_A) = [Q^a(n_A) - c(n_R)]\, n_A - p_R. \tag{12}$$

In order to align each reader's incentive to subscribe to the journal (and to 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[23] 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

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

From (10), we have

$$p_R^{FB} = -\alpha Q^a(n_A^{FB}) n_A^{FB} < 0. \tag{13}$$

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 small (but positive) price is compatible with 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 rest of society, it is optimal to subsidize readers by charging a subscription price that is lower than the marginal distribution cost. For an electronic journal, this distribution cost is zero, so that the subscription price must be negative. Summarizing, we have:

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

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

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

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

(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*

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

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 somewhat 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.[24] Therefore, we consider here the second-best outcome in which the social planner is constrained to charge a non negative subscription price ($p_R \geq 0$).

Given p_R, the marginal reader is determined by

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

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

$$c(n_R)n_A \leq \int_0^{n_A} q(x)dx. \tag{14}$$

Hence, in the second best outcome, the social planner maximizes $W(n_A, n_R)$ subject to (14). 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 (14). The first-order conditions with respect to n_A and n_R are:

$$(1+\alpha)n_R q(n_A) = (\gamma - u) + \int_0^{n_R} c(y)dy + \lambda_1 \left[c(n_R) - q(n_A)\right]; \tag{15}$$

[24] 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.

$$(1+\alpha)\int_0^{n_A} q(x)dx = n_A c(n_R) + \lambda_1 c'(n_R) n_A. \tag{16}$$

When condition (14) binds, we find from (16) that

$$(1+\alpha)c(n_R)n_A = n_A\left[c(n_R) + \lambda_1 c'(n_R)\right]$$

and thus 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 (15) gives

$$(1+\alpha)n_R q(n_A) = (\gamma - u) + \int_0^{n_R} c(y)dy + \frac{\alpha c(n_R)}{c'(n_R)}\left[c(n_R) - q(n_A)\right] \tag{17}$$

The fact that (14) binds implies that

$$c(n_R) = Q^a(n_A). \tag{18}$$

In other words, the marginal reader's reading cost is equal to the average quality of the articles published in the journal. This, together with $Q^a(n_A) > q(n_A)$ implies that when we compare (7) with (15), 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 (9) with (16) 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, characterized by (17) and (18). 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 (14) 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 :

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

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

(i) Open-access is socially optimal.

(ii) In this case, the second-best allocation $\left(n_A^{SB}, n_R^{SB}\right)$ is characterized by (17) and (18). In particular, the marginal reader's cost is equal to the average quality of published articles.

(iii) If W is quasi-concave in (n_A, n_R) then the second-best allocation involves less publications and less readers than the first-best: $n_A^{SB} < n_A^{FB}$ and $n_R^{SB} < n_R^{FB}$.

Proposition 2 characterizes the situations where open-access is optimal: when the positive externalities generated by readers (for instance through the innovations derived from academic articles) exceed the cost of distributing articles (which is zero for an Internet journal) and when subsidizing reading is not feasible (so that the first-best is not attainable), 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 as long as the marginal author's benefit from publication is larger than γ.[25] Figure 2 describes the first-best and the second-best allocations.

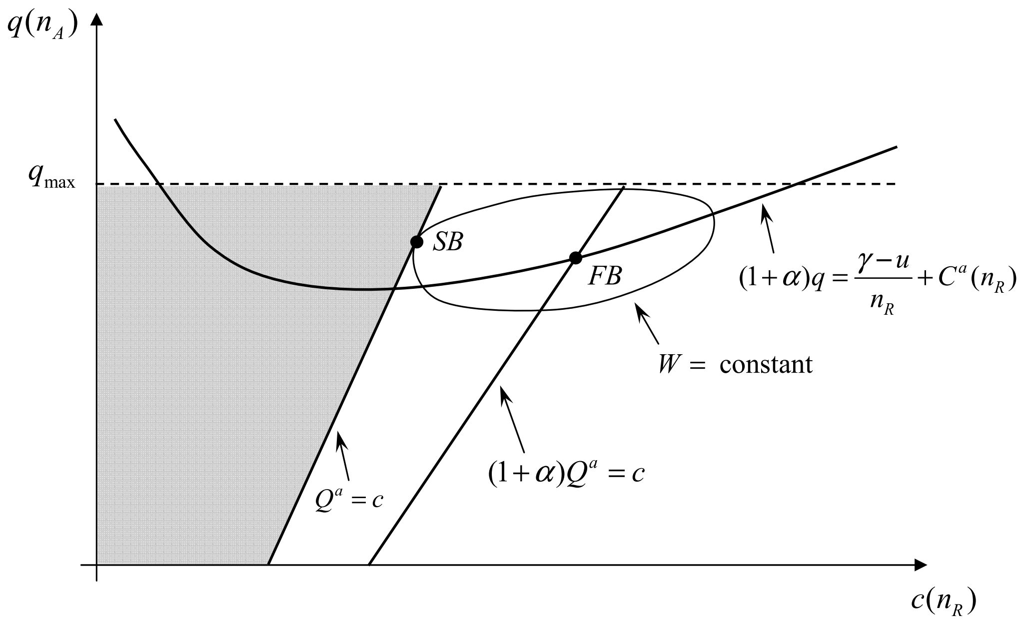

Figure 2: The first-best (FB) and the second-best (SB) allocations.
The shaded area corresponds to the region $p_R \geq 0$ (non negative reader price).

[25] In foonote 27, we give the condition under which the marginal author's benefit from publication is larger than γ for an open access not-for profit journal in the case of iso-elastic distribution functions. Since we also show later on that the journal's quality is higher under the second-best than under the open access not-for-profit journal, if the condition holds, the marginal author's benefit is larger than γ in the second-best as well.

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[26] (in this section) or the impact of the journal (in Section 7.2). 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:

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

In the reader-pays model, the author fee is zero, and the budget breaking 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 in the reader-pays model:

$$Q^a(n_A) \geq c(n_R) + \frac{\gamma}{n_R}. \tag{19}$$

Note that the feasible set under open access (where $p_R = 0$) corresponds to the same condition where γ is set equal to 0 (since γ is recovered by author fees) and the inequality is replaced by equality:

$$Q^a(n_A) = c(n_R). \tag{20}$$

[26]We here have in mind a situation in which the association maximizes its members' utilities and one becomes a member by subscribing to its journal. 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. In addition, we show that the association maximizing readers' payoffs prefers open access to reader-pays, which makes the change from reader-pays to open access consistent with the objective. On the contrary, an association maximizing authors' payoffs would prefer reader-pays to open access, which makes the change unlikely.

Since $\gamma > 0$, we see that in order to attract 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 reader-pays than under open access.

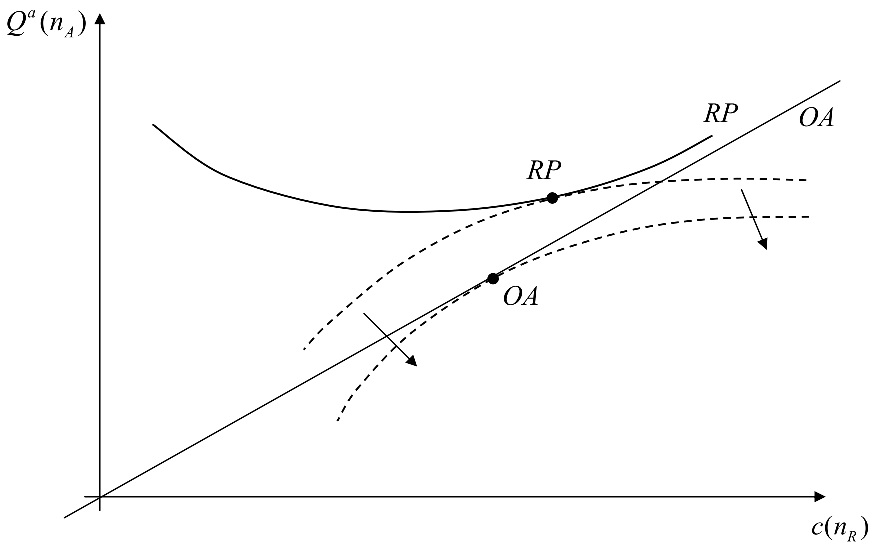

Figure 3: The reader-pays (RP) and the open-access (OA) allocations. The dashed lines correspond to the indifference curves of the association. The utility of the association increases in the direction of the arrows.

Of course, Figure 3 does not imply that open access always leads to a suboptimal level of quality. In fact, as we already noted, open access is indeed second best optimal when the association maximizes social welfare. This is why we now characterize formally the outcomes of reader-pays and open access, 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 maximize the sum of the readers' utilities given by:

$$TUR = \int_0^{n_R} \{[Q^a(n_A) - c(y)]\, n_A - p_R\}\, dy, \tag{21}$$

where TUR means total utility of readers. Since n_R and p_R have to satisfy the indifference condition of the marginal reader, i.e.

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

we can replace p_R by $[Q^a(n_A) - c(n_R)]\, n_A$ in (21). We find:

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

5.2 Reader-pays

As we already saw, the feasible set of a reader-pays journal is characterized by:

$$c(n_R) + \frac{\gamma}{n_R} \leq Q^a(n_A). \tag{22}$$

The left-hand side of (22) 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 (22) 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 (22). Define $L^{RP} = TUR - \lambda_2 \left[n_A c(n_R) n_R + \gamma n_A - n_R \int_0^{n_A} q(x)dx \right]$ where λ_2 represents the Lagrangian multiplier associated with (22). Then, the first-order conditions with respect to n_A and n_R are given by:

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

and:

$$n_A n_R c'(n_R) = \lambda_2 \left[n_A c(n_R) + n_A c'(n_R) n_R - \int_0^{n_A} q(x)dx \right]. \tag{24}$$

Since (22) is binding at the optimum, we have

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

Inserting (RP) into (23) gives:

$$\lambda_2 = \frac{c(n_R) - C^a(n_R)}{Q^a(n_A) - q(n_A)} > 0. \tag{25}$$

λ_2 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 (25) into (24) and dividing by n_A gives

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

Using (RP) and rearranging terms, we finally obtain:

$$C^a(n_R) = q(n_A) + \frac{\gamma}{n_R}\left[\frac{C^a(n_R) - c(n_R)}{n_R c'(n_R)} - 1\right]. \tag{26}$$

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 (26). Since $c'(n_R) > 0$ and $C^a(n_R) < c(n_R)$, (26) implies that $C^a(n_R) < q(n_A)$. Similarly, (RP) implies that $Q^a(n_A) > c(n_R)$.

Proposition 3 *(not-for-profit and reader-pays) Consider a not-for-profit journal run by an association maximizing the total utility of its readers. Under reader-pays, the allocation chosen by the association* $\left(n_A^{RP}, n_R^{RP}\right)$ *is characterized by* (RP) *and (26). In particular:*

- *the average quality of published articles is higher than the reading cost of the marginal reader, and*
- *the average reading cost is lower than the quality of the marginal article.*

5.3 Open access

Before studying open access, we note first that in our model, the association maximizing readers' utilities prefers open access to reader-pays as long as the marginal author's benefit from publication is larger than γ.[27] The association can at least choose the same quality standard that is chosen under reader-pays: then the change to open access increases the number of readers and hence increases the sum of readers' utilities. This argument also shows that the association prefers open access to any hybrid model in which the journal combines author fee with a positive subscription price.

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:

[27] In the case of the iso-elastic distribution functions that we consider in section 6, the marginal author's benefit under open access is larger than γ if the following condition holds:

$$\frac{\alpha_A}{1+\varepsilon_c}\left[\frac{\varepsilon_q}{\varepsilon_q + \frac{\varepsilon_c}{1+\varepsilon_c}} q_{\max}\right]^{\frac{1+\varepsilon_c}{\varepsilon_c}} > (\gamma - u)\left(c_{\max}\right)^{\frac{1}{\varepsilon_c}}.$$

Note that this condition holds if $q_{\max}$ or α_A is large enough or $c_{\max}$ is small enough.

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

and the authors' participation constraint:

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

Note that p_A does not appear in the objective of the association. Without loss of generality, we assume that the association selects the lowest price that is compatible with (BB), namely $p_A = \gamma$. 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 $L^{OA} = TUR - \lambda_3 \left[c(n_R) n_A - \int_0^{n_A} q(x) dx \right]$ where λ_3 represents the Lagrangian multiplier associated with (OA). Then, the first-order conditions with respect to n_A and n_R are given by:

$$\int_0^{n_R} [c(n_R) - c(y)] \, dy = \lambda_3 [c(n_R) - q(n_A)] \, ; \tag{27}$$

$$n_A n_R c'(n_R) = \lambda_3 n_A c'(n_R). \tag{28}$$

(28) is equivalent to

$$\lambda_3 = n_R > 0. \tag{29}$$

λ_3 represents the marginal increase in TUR that would be achieved if the association could subsidize readers. Replacing λ_3 with n_R in (27) gives:

$$q(n_A) = \frac{\int_0^{n_R} c(y) dy}{n_R} (\equiv C^a(n_R)). \tag{30}$$

Let $\left(n_A^{OA}, n_R^{OA}\right)$ denote the association's optimal choice under open access. It is characterized by (OA) and (30). (OA) means that the average quality is equal to the reading cost of the marginal reader. In a somewhat symmetric fashion, condition (30) means that the average reading cost $C^a(n_R)$ is equal to the quality of the marginal author's article.

Proposition 4 *(not-for-profit and open-access) Consider a not-for-profit journal run by an academic association maximizing the total utility of its readers. 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 published articles is equal to the reading cost of the marginal reader, and*
- *the average reading cost is equal to the quality of the marginal article.*

6 Comparison of all four cases

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":[28]

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

In our iso-elastic specification we have:

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

or equivalently:

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

and

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

In the appendix, we characterize all four outcomes in the case of iso-elastic distributions.

6.1 Average quality

Proposition 5 *(average quality): Consider a not-for-profit journal run by an academic association maximizing the total utility of its readers. In the case of iso-elastic distributions, we have:*

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

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

Proof. See the appendix. ■

Note that Q^{aOA} and Q^{aRP} depend neither on the externality parameter α nor on authors' fixed benefit u since the association does not internalize them. Furthermore, under open access, γ has no impact on the quality choice of the association since there

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

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. But the social planner internalizes the net publication cost $\gamma - u$. Therefore, as long as $\gamma - u$ is positive, because of the lack of budgetary discipline, the association publishes too many articles under open-access: $Q^{aOA} < Q^{aSB}$.

Under the reader-pays model, the association has to recover the entire γ by charging readers. By contrast, what matters for the social planner is $\gamma - u$. This, together with the fact that the association does not internalize the authors' benefit, makes the reader-pays association publish too few articles compared to the second-best: $Q^{aRP} > Q^{aSB}$.

The intuition for why the change from reader-pays to open access induces a quality degradation can be given in two steps. First, given the quality standard chosen under the reader-pays model $q_{\min} = q(n_A^{RP})$, the move to open access increases the number of readers to n'_R determined by $c(n'_R) = Q^a(n_A^{RP})$. Second, in the case of iso-elastic distributions, the condition $q(n_A^{RP}) > C^a(n'_R)$ holds, which implies that the association finds it optimal to lower the standard to publish more articles. Basically, the reader-pays model imposes more discipline on quality than the open-access model since the former needs to recover the publication cost from subscription price and therefore attracting the same number of readers requires the former to provide a higher quality than the latter.

The following table compares the determinants of average quality of published articles in the four regimes. It is easy to see that since, in all four equations of table 1, the left hand side of each equation increases with Q^a, the unique solution exists as long as $q_{\max}$ is large enough.

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

Table 1: Average Qualities.

6.2 Readership size

Table 2 below compares the determinants of readership size in the four regimes. First, comparing the first-best outcome with the second-best, we find:

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

which implies $n_R^{FB} > n_R^{SB}$. Furthermore, under open-access the marginal reader is determined by the average quality of articles (i.e. $Q^a = c(n_R)$). Since, by Proposition 5, the average quality is higher under the second-best than with an open-access association (i.e. $Q^a(n_A^{SB}) > Q^a(n_A^{OA})$) 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. The comparison gives

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

If $\varepsilon_q > \frac{1}{1+\varepsilon_c}$, 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. But a rather surprising result holds if $\varepsilon_q < \frac{1}{1+\varepsilon_c}$: in this case open-access reduces readership size. This occurs because even though readers do not pay for subscription, the average quality of the journal is so low under open access. Basically, there is a conflict between low cost readers and high cost readers over the choice of quality standard: the former prefers a low standard while the latter prefers a high standard. When $\varepsilon_q < \frac{1}{1+\varepsilon_c}$, the conflict is severe[29] and hence resolving the conflict in favor of low cost readers by lowering quality standard induces many high cost readers to stop reading the journal.

First-Best	$\left(\varepsilon_q + \dfrac{\varepsilon_c}{1+\varepsilon_c}\right) c - \dfrac{(\gamma - u)(c_{\max})^{1/\varepsilon_c}}{c^{1/\varepsilon_c}} = (1+\alpha)\varepsilon_q q_{\max}$
Second-Best	$\left(\varepsilon_q + \dfrac{\varepsilon_c}{1+\varepsilon_c}\right) c - \dfrac{(\gamma - u)(c_{\max})^{1/\varepsilon_c}}{(1+\alpha+\frac{\alpha}{\varepsilon_c})c^{1/\varepsilon_c}} = \varepsilon_q q_{\max}$
Open-Access	$\left(\varepsilon_q + \dfrac{\varepsilon_c}{1+\varepsilon_c}\right) c(n_R) = \varepsilon_q q_{\max}$
Reader-Pays	$\left(\varepsilon_q + \dfrac{\varepsilon_c}{1+\varepsilon_c}\right) c(n_R) + \dfrac{\gamma}{n_R}\left(\varepsilon_q - \dfrac{1}{1+\varepsilon_c}\right) = \varepsilon_q q_{\max}$

Table 2: Readership Sizes.

[29] For instance, a small ε_c means that a small change in c creates a large change in n_R. Therefore, as ε_c decreases, a given quality degradation, that induces a decrease in the marginal c through $Q^a = c$, induces a larger reduction in n_R.

Summarizing, we have:

Proposition 6 *(readership size): Consider a not-for-profit journal run by an academic association maximizing the total utility of its readers. In the case of iso-elastic distributions, we have:*

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

The journal attracts too few readers under the open-access model. Moreover:

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

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

Figures 4 and 5 illustrate the allocations chosen by the association under open access and under reader-pays together with the second-best allocation.

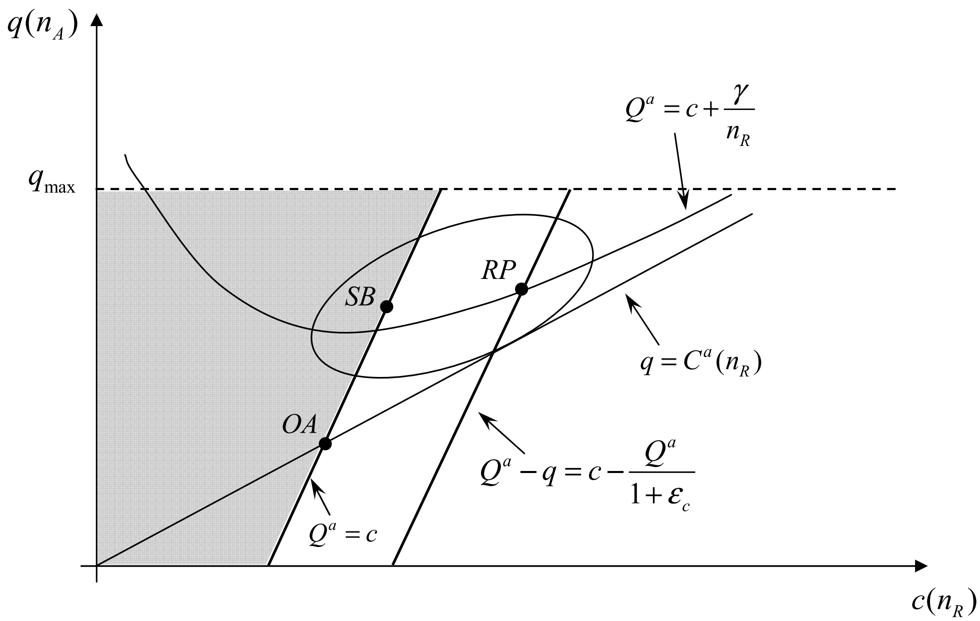

Figure 4: The allocations chosen by a not-for-profit journal when $\varepsilon_q < \frac{1}{1+\varepsilon_c}$ (*OA*: open-access, *RP*: reader-pays).

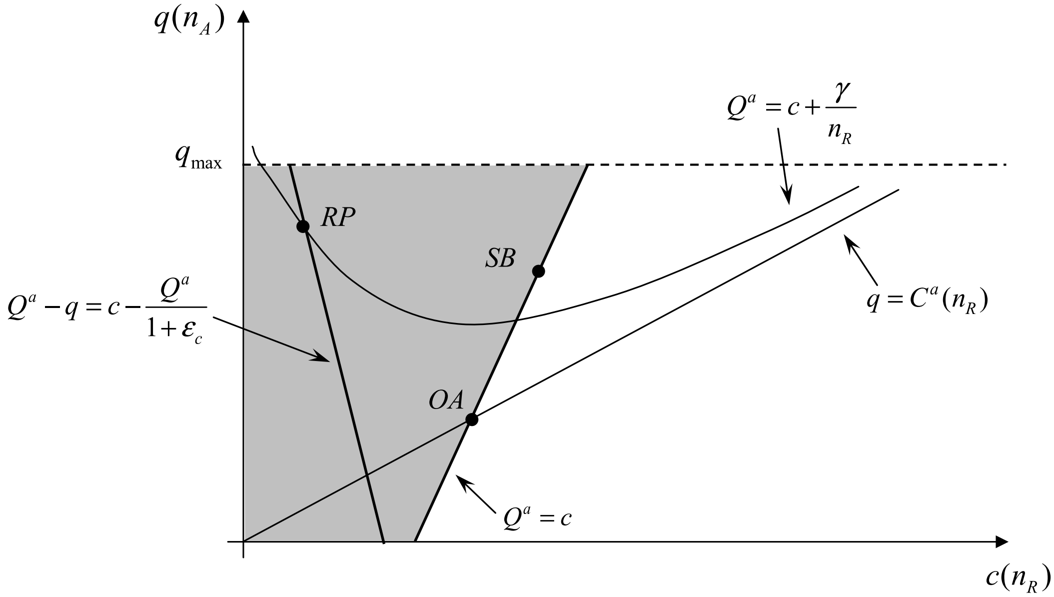

Figure 5: The allocations chosen by a not-for-profit journal when $\varepsilon_q > \frac{1}{1+\varepsilon_c}$ (OA: open-access, RP: reader-pays).

7 Robustness

In this section, we show that our main result that open access can lead to quality degradation is robust for the two-sided pricing model where both authors and readers pay and also for different specification of objectives of the journal (maximization of impact or profit).

7.1 The Two-sided pricing model

In the previous section, we assumed that under open access, the not-for-profit journal maximizing readers' utilities can recover the entire publication cost through author fees and studied the transition from the reader-pays model to open access. Here, we consider the case in which the journal cannot recover the entire publication cost through author fees because of the authors' budget constraint and hence study the transition from the reader-pays model to the two-sided pricing model in which the journal complements author fee with a positive subscription price.

Let $B(< \gamma)$ be the maximum amount authors can pay. Under the two-sided pricing model, the journal charges an author fee equal to B and recovers $(\gamma - B)n_A$ through a subscription price:

$$p_R n_R = (\gamma - B) n_A.$$

Let $\gamma' \equiv \gamma - B$. Then, the two-sided pricing model is equivalent to a reader-pays model in which γ is replaced by γ'. Hence, we need to know how the quality standard under the reader-pays model changes as γ decreases. In what follows, we show that this quality standard decreases as γ decreases in the case of iso-elastic distribution functions. Consider first the case with $\varepsilon_q \geq \frac{1}{1+\varepsilon_c}$. We suppose that γ strictly decreases but Q^a weakly increases and find a contradiction. Note first that a strict decrease in γ together with a weak increase in Q^a implies that c strictly increases. This is because c is the maximum value satisfying

$$\text{(RP)} \quad Q^a = c + \frac{\gamma (c_{\max})^{1/\varepsilon_c}}{c^{1/\varepsilon_c}}.$$

After substituting $\frac{\gamma(c_{\max})^{1/\varepsilon_c}}{c^{1/\varepsilon_c}}$ with $Q^a - c$ into the following equation that characterizes the optimal Q^a,

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

we find:

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

Since the L.H.S. of the above equation strictly increases but the R.H.S. remains unchanged, we have a contradiction. Therefore, the move to the two-sided pricing case generates quality degradation as long as $\varepsilon_q > \frac{1}{1+\varepsilon_c}$.

Consider now $\varepsilon_q < \frac{1}{1+\varepsilon_c}$. From the following equation that characterizes the optimal n_R,

$$\left(\varepsilon_q + \frac{\varepsilon_c}{1+\varepsilon_c}\right) c_{\max} n_R^{\varepsilon_c} + \frac{\gamma}{n_R} \left(\varepsilon_q - \frac{1}{1+\varepsilon_c}\right) = \varepsilon_q q_{\max}$$

we find

$$\frac{dn_R}{d\gamma} = \frac{-\left(\varepsilon_q - \frac{1}{1+\varepsilon_c}\right)}{\left[\left(\varepsilon_q + \frac{\varepsilon_c}{1+\varepsilon_c}\right) \varepsilon_c c_{\max} n_R^{\varepsilon_c} - \frac{\gamma}{n_R}\left(\varepsilon_q - \frac{1}{1+\varepsilon_c}\right)\right]} > 0.$$

This implies that as γ decreases, the number of readers n_R (and hence $c(n_R)$) strictly decreases. However, from (RP), c cannot decrease if γ decreases and Q^a weakly increases. Therefore, Q^a must strictly decrease. Summarizing we have:

Proposition 7 *Consider the not-for-profit journal maximizing the sum of the readers' payoffs. When the author is budget constrained with $B(< \gamma)$, in the case of iso-elastic distribution functions, the change from the reader-pays model to the two-sided pricing model:*

(i) always induces a quality degradation.

(ii) also reduces the number of readers if $\varepsilon_q < \frac{1}{1+\varepsilon_c}$ *holds.*

7.2 Impact-maximizing journal

Maximizing the utility of readers is a reasonable objective for a reader-pays (not-for-profit) journal, since readers are also the members of the association that controls the journal. However this objective may seem less natural for an open-access journal. Thus the move from reader-pays 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 endeavors to maximize its impact, measured by the sum of all readers' benefit from reading the journal:

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

IM is also proportional to the number of citations of the article, or to the number of patents derived from it.

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

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

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

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

As before, p_A does not appear in the objective of the association. Without loss of generality, we assume that the association selects the lowest price that is compatible with (BB), namely $p_A = \gamma$. In what follows, we study the association's choice of (n_A, n_R) assuming that (PC_A) is slack at $p_A = \gamma$.[30]

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:

$$n_R q(n_A) = \lambda_4 \left[c(n_R) - q(n_A)\right]; \tag{31}$$

[30] In the case of the iso-elastic distribution functions, (PC_A) is slack at $p_A = \gamma$ if the following condition holds:

$$\frac{\alpha_A}{1+\varepsilon_c}\left[\frac{\varepsilon_q}{\varepsilon_q + \frac{\varepsilon_c}{1+\varepsilon_c}} q_{\max}\right]^{\frac{1+\varepsilon_c}{\varepsilon_c}} > (\gamma - u)(c_{\max})^{1/\varepsilon_c}.$$

Note that this condition holds if $q_{\max}$ or α_A is large enough or $c_{\max}$ is small enough.

$$\int_0^{n_A} q(y)dy = \lambda_4 n_A c'(n_R). \tag{32}$$

(32) is equivalent to

$$\lambda_4 = \frac{\int_0^{n_A} q(y)dy}{n_A c'(n_R)} > 0. \tag{33}$$

λ_4 represents the marginal increase in the impact of the journal that would occur if the association could subsidize readers. Replacing λ_4 in (31) with the expression in (33) gives:

$$n_R q(n_A) c'(n_R) = Q^a(n_A) \left[c(n_R) - q(n_A)\right]. \tag{34}$$

Since (OA) is binding, we have that $Q^a(n_A) = c(n_R)$. Rearranging (34) gives:

$$q(n_A) = \frac{c(n_R)}{1 + \frac{n_R c'(n_R)}{c(n_R)}}. \tag{35}$$

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 (35) 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 (30) (marginal quality equals average readers cost) coincides in this case with condition (35), since:

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

Proposition 8 *(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 (35).*

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

Proposition 8 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 below the socially efficient level. Therefore, the move to open-access is likely to result in the publication of too many articles from a social welfare viewpoint.

7.3 For-profit journal

As another robustness check, we consider here the case of a for-profit journal. Since this case is more complex, we use a simpler version of our model in which all readers are homogenous and have the same reading cost per article $c > 0$. As before, authors differ in terms of the quality of their article, but the distribution of qualities is now binomial: a fraction ν of authors have articles of high quality, denoted by q_H, and a fraction $1 - \nu$ of authors have articles of low quality, denoted by $q_L \in (0, q_H)$. We introduce two assumptions:

A1: $\nu q_H + (1 - \nu)q_L < c$.

A2: (viability) $(q_H - c) > \gamma$ and $u + \alpha_A q_H > \gamma$

A1 says that if all articles are accepted, the average quality is lower than the reading cost, which implies that in this case no reader reads the journal. In other words, A1 says that in the absence of the certification service provided by the journal, no reader has an incentive to read articles at random. A2 says that if the journal publishes only high-quality articles, the journal is viable both under the reader-pays model and under the open-access model. More precisely, if all readers read a high quality article, under reader-pays, the sum of readers' net benefits from reading it is larger than the publication cost and, under open access, the author's benefit is larger than the publication cost.

The journal's editorial policy consists of the probability of accepting a high-quality article, denoted by β_H, and the probability of accepting a low-quality article, denoted by β_L, where a low-quality article can be published (i.e. $\beta_L > 0$) only if $\beta_H = 1$. Equivalently, this editorial policy can be interpreted in terms of the minimum quality standard q_{min} and the number of articles to publish n_A with prioritization of high quality articles. To simplify our analysis, we assume that the refereeing cost is zero and hence the submission fee is zero.

7.3.1 Benchmark: Second best

We study the social optimum under the constraint that the social planner cannot force a reader to read the journal when the average quality of the journal is below the reading cost. From A2, all high-quality articles should be published (i.e. $\beta_H = 1$). Regarding β_L, let $\overline{\beta}_L$ be defined by

$$\frac{\nu q_H + (1 - \nu)\overline{\beta}_L q_L}{\nu + (1 - \nu)\overline{\beta}_L} \equiv c,$$

which is equivalent to:

$$(1 - \nu)\overline{\beta}_L(c - q_L) = \nu(q_H - c).$$

According to A1 and A2, such $\overline{\beta}_L$ exists and $\overline{\beta}_L \in (0, 1)$. It is not optimal to choose $\beta_L > \overline{\beta}_L$ since in this case the journal will not be read. For $\beta_L \leq \overline{\beta}_L$, social welfare from publishing low quality articles is given by

$$SW_L(\beta_L) = (1-\nu)\beta_L\left[(1+\alpha)q_L - (\gamma - u) - c\right].$$

If a low-quality article is published, the gain to society is $u+(1+\alpha)q_L$ while society incurs the publication cost γ and the reading cost c. Therefore, $\beta_L = \overline{\beta}_L$ is optimal if and only if $u+(1+\alpha)q_L \geq \gamma + c$: otherwise, $\beta_L = 0$ is optimal.

7.3.2 Reader-pays

Consider now a reader-pays for-profit journal. Define the average quality of the journal as follows:

$$Q^a(\beta_H, \beta_L) \equiv \frac{\nu\beta_H q_H + (1-\nu)\beta_L q_L}{\nu\beta_H + (1-\nu)\beta_L}$$

The profit is zero if the average quality is lower than the reading cost. Otherwise, the maximum price that the journal can charge a reader for subscription is $[\nu\beta_H + (1-\nu)\beta_L](Q^a - c)$. Therefore, the profit is given by

$$\begin{aligned}\Pi^{RP}(\beta_H, \beta_L) &= [\nu\beta_H + (1-\nu)\beta_L]\,[Q^a(\beta_H, \beta_L) - c - \gamma] \\ &= [\nu\beta_H q_H + (1-\nu)\beta_L q_L] - [\nu\beta_H + (1-\nu)\beta_L](c+\gamma)\end{aligned}$$

Profit maximization leads to $\beta_H = 1$ from A2 and $\beta_L = 0$ from A1.

7.3.3 Open Access

Consider now an open access for-profit journal. As before, the profit is zero if the average quality is lower than the reading cost. Otherwise, the maximum price that the journal can charge for publication is $u+\alpha_A q_H$ if $\beta_L = 0$ or $u+\alpha_A q_L$ if $\beta_L > 0$. Hence, if $u+\alpha_A q_L \leq \gamma$, the journal will not publish any low quality articles (i.e. $\beta_L = 0$) and will choose $\beta_H = 1$ from A2; this outcome is equivalent to the one under the reader-pays for-profit journal. When $u + \alpha_A q_L > \gamma$, conditional on $\beta_L > 0$, profit maximization leads to $\beta_L = \overline{\beta}_L$ (and $\beta_H = 1$). In this case, we need to compare the profit obtained when $(\beta_H, \beta_L) = (1, 0)$ with the one obtained when $(\beta_H, \beta_L) = (1, \overline{\beta}_L)$. The difference between the two is

$$\begin{aligned}&\nu(u+\alpha_A q_H - \gamma) - \left[\nu + (1-\nu)\overline{\beta}_L\right](u + \alpha_A q_L - \gamma) \\ =\ &\nu\alpha_A(q_H - q_L) - (1-\nu)\overline{\beta}_L(u+\alpha_A q_L - \gamma)\end{aligned}$$

Therefore, the journal chooses $(\beta_H, \beta_L) = (1, \overline{\beta}_L)$ if and only if

$$u - \gamma + \alpha_A q_L \geq \frac{\nu\alpha_A(q_H - q_L)}{(1-\nu)\overline{\beta}_L} = \frac{\alpha_A(q_H - q_L)(c - q_L)}{(q_H - c)}.$$

Otherwise, the journal chooses $(\beta_H, \beta_L) = (1, 0)$.

Summarizing, we have:

Proposition 9 *Under A1-A2, (i) high quality articles are always published under any of the three cases: second-best, reader-pays for-profit, open access for-profit.*

(ii) As for low quality articles:

a. In the second best outcome, $\beta_L = \overline{\beta}_L$ is optimal if and only if $u - \gamma + (1+\alpha)q_L \geq c$: otherwise, $\beta_L = 0$ is optimal.

b. A reader-pays for-profit journal always chooses $\beta_L = 0$.

c. An open access for-profit journal chooses $\beta_L = \overline{\beta}_L$ if and only if

$$u - \gamma + \alpha_A q_L \geq \frac{\alpha_A (q_H - q_L)(c - q_L)}{(q_H - c)}.$$

Otherwise, it chooses $\beta_L = 0$.

Corollary 1 *(i) The quality standard chosen by a reader-pays for-profit journal is (weakly) higher than both the one chosen by an open-access for-profit journal and the second best quality standard. Therefore, the change from the reader-pays model to open access (weakly) creates quality degradation.*

(ii) If c is larger than $u - \gamma + (1+\alpha)q_L$, the quality standard chosen by an open access for-profit journal is also (weakly) lower than the second best standard.

A reader-pays for-profit journal has no interest in publishing low quality articles since including any low quality article only reduces readers' willingness to pay for the subscription. However, publishing a low quality article may be socially desirable when the positive externalities on the society are large enough. Therefore, a reader-pays for profit journal tends to have too high a standard since it does not internalize these externalities. On the contrary, an open access for-profit journal does not internalize readers' reading costs as long as the average quality of the journal is larger than the reading cost per article c. Therefore, it may have an incentive to degrade the quality by publishing low quality articles until the average quality of the journal becomes equal to c. This quality degradation is profitable as long as the positive effect from publishing more articles dominates the negative effect from reducing the author fee (since an author's benefit is larger when publishing a high-quality article than when publishing a low quality article). Therefore, if publishing low quality articles is not socially desirable because of a high c, the change from the reader-pays model to open access weakly creates quality degradation.

8 Concluding remarks

We showed that in the case of an electronic journal, social welfare maximization implies open access in the second best world in which the subscription price cannot be negative. This is because the marginal cost of distribution is zero, while readers exert positive externalities on the rest of society. We also examined the consequences of a move from the reader-pays model to the open-access model by considering academic journals run by not-for-profit associations or by for-profit publishers. In the case of a for-profit journal, the move can generate degradation of the journal's quality standard below socially efficient level since the journal does not internalize reading cost under open access and hence has an incentive to publish low quality articles to increase its profit from author fees. What is rather surprising is that the change to open access can generate quality degradation even for a not-for-profit journal maximizing readers' payoffs (and hence internalizing reading cost). The basic intuition is simple: under open access, the association does not internalize the cost of publication (which is covered by author fees) 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. Furthermore, quality degradation can even make the number of readers under open access smaller than the number under the reader-pays model when the conflicts between low cost readers and high cost readers over the quality standard are severe.

Even though we did not model library subscriptions under reader-pays model, our main results on the move from reader-pays and open access seem to be robust as long as we maintain the assumption that the journal charges a single subscription price. Note first that library subscription plays no role under open access. Under reader-pays model, as a first approximation, we can reinterpret a reader in our model as a group of readers for which a library makes the subscription decision. Then, a library will subscribe only if the total benefit of its group is larger than the sum of the subscription price and the total reading cost of its group. Hence, library subscription decisions would impose some discipline on the quality standard of the reader-pays model.

It would be interesting to extend our analysis to the case in which the journal can give an accepted article one among several ratings according to its quality. For instance, some B.E. journals in economics give one among three quality ratings (Advances, Contributions, Topics).[31]

[31] The simple model we considered in section 7.3 shows that publishing some low quality articles together with high quality articles can be socially optimal when articles generate large positive externalities on the society. In this case, completely revealing each article's quality reduces social welfare since then readers will read only high quality articles.

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"[32] according to which the change from reader-pays to open access would promote competition. Indeed, once articles are published in journals, each journal is a bottleneck and has a monopoly power on its content; however, at the submission stage (i.e. prior to publication) journals are substitutes and compete for attracting authors.

[32]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 al., 2006, p.67).

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Appendix

Characterization of all four outcomes in the case of iso-elastic distributions

In what follows, we characterize all four outcomes (the first-best, the second-best, the allocations chosen by the association maximizing readers' payoffs under reader-pays and under open access) in the case of iso-elastic distributions.

1. The first-best allocation

The first-best allocation is characterized by two conditions:

$$(1+\alpha)q(n_A) = \frac{\gamma - u}{n_R} + C^a(n_R), \tag{8}$$

and

$$(1+\alpha)\int_0^{n_A} q(x)dx = n_A c(n_R). \tag{9}$$

Condition (8), expressed in terms of (q, c) leads to:

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

Condition (9), expressed in terms of the same variables leads to:

$$(1+\alpha)\left[\varepsilon_q q_{\max} + q\right] = (1+\varepsilon_q)c. \tag{37}$$

Substracting (36) from (37) leads to:

$$\left(\varepsilon_q + \frac{\varepsilon_c}{1+\varepsilon_c}\right) c - \frac{(\gamma - u)(c_{\max})^{1/\varepsilon_c}}{c^{1/\varepsilon_c}} = (1+\alpha)\varepsilon_q q_{\max}. \quad (38)$$

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 (38), denoted $c^{FB} \equiv c(n_R^{FB})$. Replacing c by $(1+\alpha)Q^a$ (this results from (9)) into (38) and dividing (38) by $(1+\alpha)$ gives:

$$\left(\varepsilon_q + \frac{\varepsilon_c}{1+\varepsilon_c}\right) Q^a - \frac{(\gamma - u)(c_{\max})^{1/\varepsilon_c}}{(1+\alpha)^{1+1/\varepsilon_c}(Q^a)^{1/\varepsilon_c}} = \varepsilon_q q_{\max}. \quad (39)$$

$Q^{aFB} \equiv Q^a(n_A^{FB})$ is the unique solution of (39).

2. The second-best allocation

It is characterized by two conditions:

$$(1+\alpha)q(n_A) = \frac{(\gamma - u)}{n_R} + \frac{\int_0^{n_R} c(y)dy}{n_R} + \frac{\alpha c(n_R)}{n_R c'(n_R)}\left[c(n_R) - q(n_A)\right] \quad (17)$$

and

$$c(n_R) = Q^a(n_A). \quad (18)$$

After replacing $n_R c'(n_R) = \varepsilon_c c(n_R)$ into (17) and expressing everything in terms of (q, c), we obtain:

$$(1+\alpha+\frac{\alpha}{\varepsilon_c})q = \frac{(\gamma - u)(c_{\max})^{1/\varepsilon_c}}{c^{1/\varepsilon_c}} + \frac{c}{1+\varepsilon_c} + \frac{\alpha c}{\varepsilon_c},$$

from which we get:

$$q = \frac{(\gamma - u)(c_{\max})^{1/\varepsilon_c}}{\left(1+\alpha+\frac{\alpha}{\varepsilon_c}\right) c^{1/\varepsilon_c}} + \frac{c}{1+\varepsilon_c} \quad (40)$$

Since $q = (1+\varepsilon_q)Q^a - \varepsilon_q q_{\max} = (1+\varepsilon_q)c - \varepsilon_q q_{\max}$ (the latter equality results from (18)), condition (40) becomes:

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

$c^{SB}\left(\equiv c(n_R^{SB})\right)$ is the unique solution of (41). Furthermore, we have $c^{SB} = Q^{aSB} \equiv Q^a(n_A^{SB})$.

3. Reader-pays

The allocation chosen under the reader-pays model is characterized by two conditions:

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

and

$$C^a(n_R) = q(n_A) + \frac{\gamma}{n_R}\left[\frac{C^a(n_R) - c(n_R)}{n_R c'(n_R)} - 1\right]. \tag{30}$$

Since $c = c_{\max} n_R^{\varepsilon_c}$, (RP) is equivalent to

$$Q^a = c + \frac{\gamma (c_{\max})^{1/\varepsilon_c}}{c^{1/\varepsilon_c}}. \tag{42}$$

If we express (26) as a function of c, using $C^a = \frac{1}{1+\varepsilon_c} c$, $q = (1+\varepsilon_q)Q^a - \varepsilon_q q_{\max}$ and (42), we get

$$\frac{c}{1+\varepsilon_c} = (1+\varepsilon_q)\left[c + \frac{\gamma (c_{\max})^{1/\varepsilon_c}}{c^{1/\varepsilon_c}}\right] - \varepsilon_q q_{\max} + \frac{\gamma (c_{\max})^{1/\varepsilon_c}}{c^{1/\varepsilon_c}}\left[\frac{\frac{c}{1+\varepsilon_c} - c}{\varepsilon_c c} - 1\right],$$

and after simplifications:

$$\left(\varepsilon_q + \frac{\varepsilon_c}{1+\varepsilon_c}\right)c - \frac{\gamma (c_{\max})^{1/\varepsilon_c}\left(\frac{1}{1+\varepsilon_c} - \varepsilon_q\right)}{c^{1/\varepsilon_c}} = \varepsilon_q q_{\max}. \tag{43}$$

4. Open access

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

$$q(n_A) = \frac{\int_0^{n_R} c(y)dy}{n_R} (\equiv C^a(n_R)). \tag{25}$$

¿From $q = (1+\varepsilon_q)Q^a - \varepsilon_q q_{\max}$, (30) becomes

$$(1+\varepsilon_q)Q^a - \varepsilon_q q_{\max} = \frac{c}{1+\varepsilon_c} \tag{44}$$

Replacing c with Q^a in (44) gives Q^{aOA}

$$\left(\varepsilon_q + \frac{\varepsilon_c}{1+\varepsilon_c}\right) Q^{aOA} = \varepsilon_q q_{\max}. \tag{45}$$

Proof of Proposition 5

When we replace c with Q^a in (41), compare it with (39), and use the fact that $(1+\alpha)^{1+1/\varepsilon_c} > (1+\alpha+\frac{\alpha}{\varepsilon_c})$, we find

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

It is easy to compare the first-best allocation with the allocation chosen by an open-access association in terms of average quality. Indeed, comparing (39) with (45) tells us immediately that

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

We now compare the second-best allocation with the reader-pays outcome, again in terms of average quality. Replacing c with $Q^a - \frac{\gamma(c_{\max})^{1/\varepsilon_c}}{c^{1/\varepsilon_c}}$ into the first term of (43) gives

$$\begin{aligned} &\left(\varepsilon_q + \frac{\varepsilon_c}{1+\varepsilon_c}\right)\left(Q^a - \frac{\gamma(c_{\max})^{1/\varepsilon_c}}{c^{1/\varepsilon_c}}\right) - \frac{\gamma(c_{\max})^{1/\varepsilon_c}}{c^{1/\varepsilon_c}}\left(\frac{1}{1+\varepsilon_c} - \varepsilon_q\right) \\ = &\left(\varepsilon_q + \frac{\varepsilon_c}{1+\varepsilon_c}\right) Q^a - \frac{\gamma(c_{\max})^{1/\varepsilon_c}}{[\tilde{c}(Q^a)]^{1/\varepsilon_c}} = \varepsilon_q q_{\max}, \end{aligned} \tag{46}$$

where $\tilde{c}(Q^a)$ is the largest c that satisfies (42). This function is defined for

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

As already mentioned, we assume that $q_{\max}$ is large enough for this set to be non empty. In this case, Q^{aRP} is determined by (46). $Q^a > \tilde{c}(Q^a)$ implies

$$\left(\varepsilon_q + \frac{\varepsilon_c}{1+\varepsilon_c}\right) Q^a - \frac{\gamma(c_{\max})^{1/\varepsilon_c}}{(Q^a)^{1/\varepsilon_c}} > \left(\varepsilon_q + \frac{\varepsilon_c}{1+\varepsilon_c}\right) Q^a - \frac{\gamma(c_{\max})^{1/\varepsilon_c}}{[\tilde{c}(Q^a)]^{1/\varepsilon_c}}. \tag{47}$$

Let $\widetilde{Q}^a$ denote the solution of

$$\left(\varepsilon_q + \frac{\varepsilon_c}{1+\varepsilon_c}\right) Q^a - \frac{\gamma(c_{\max})^{1/\varepsilon_c}}{(Q^a)^{1/\varepsilon_c}} = \varepsilon_q q_{\max}. \tag{48}$$

Note that the left hand side of (47) increases with Q^a, while the right hand side equals $\varepsilon_q q_{\max}$ when $Q^a = Q^{aRP}$, by condition (46). Then, (46) and (47) imply that $\widetilde{Q}^a < Q^{aRP}$. Comparing (48) with (41) (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:

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

remark to Marie-Pierre, table 1 should be changed as follows except the equation for open access

first-best

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

second-best

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

open access: the same as before

reader-pays:

$$\left(\varepsilon_q + \frac{\varepsilon_c}{1+\varepsilon_c}\right) Q^a - \frac{\gamma(c_{\max})^{1/\varepsilon_c}}{[\widetilde{c}(Q^a)]^{1/\varepsilon_c}} = \varepsilon_q q_{\max}.$$

where $\widetilde{c}(Q^a)$ is the largest solution of $Q^a = c + \frac{\gamma(c_{\max})^{1/\varepsilon_c}}{c^{1/\varepsilon_c}}$.