E C O N O M I C S   B U L L E T I N

Coping with journal−price inflation: leading policy proposals and the quality−spectrum

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Abstract

This paper presents a simple model in which research universities stock their libraries with academic journals by picking a threshold level of quality below which no subscriptions are ordered. This framework is used to analyze two sets of initiatives aimed at dealing with journal−price inflation: (1) promoting low−cost modes of production and distribution, e.g., e−journals, and (2) changing tenure and promotion requirements in order to reduce the incentive for scholars to prioritize quantity over quality. Although these initiatives are, in the author's view, laudable in many respects, the model makes the point that the range of quality among journals that libraries subscribe to may shrink as a result. If there are gaps between contemporary standards of ``quality'' in academic publishing, and what turns out to be useful to society in the long−run, then a ``scholarly communication'' policy that is sensitive to pluralism with respect to journal−quality is recommended.

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This paper studies a one-period decision problem in which a research university attempts to pick the quantity and quality of academic journals, along with other inputs, to maximize its output of knowledge.[1] A key simplifying assumption in this paper, supported by interviews with research librarians collected in order to learn about actual journal-acquisition decisions, is that universities make changes in their journal holdings primarily by changing a variable referred to here as the *quality-cut-off-point,* i.e., the threshold level of quality below which no subscriptions are acquired. Although universities are moderately price-sensitive within a particular stratum of quality (for instance, canceling a high-quality journal whose price is five times that of its high-quality peers), most of the change in the quantity of journal holdings is accomplished by raising or lowering the quality-cut-off-point. Therefore, this paper attempts to develop an equilibrium model for studying the choice of the quality-cut-off-point, separating a continuous range of quality levels into two discrete "subscribe" and "don't subscribe" regions. The size of the "subscribe" region is referred to as the *quality-spectrum* (or *breadth of quality*).

The quality-cut-off-point model helps to analyze how different policy approaches to dealing with high levels of journal-price inflation might affect the range of quality that characterizes a typical research university's journal holdings. Thus, the paper's main findings concern the connection between policies aimed at organizing a more efficient mechanism for producing and distributing "scholarly communication," and the quality-spectrum. The primary motivation for studying this connection stems from the possibility that some "scholarly communication" policies, while beneficially reducing the cost of acquiring journals in the aggregate, may have the un-intended consequence of shrinking the quality-spectrum.[2]

If there is a gap between the meaning of "quality" as libraries and journal-acquisition committees measure it, and the meaning of "quality" implicit in society's social-welfare function, then shrinking the quality-spectrum has the potential to be socially harmful. Such a gap may arise simply because of measurement error, due to the inherent difficulty of determining

[1] Of course, universities may have objectives other than "to produce knowledge." But for the purpose of analyzing policy proposals aimed at dealing with the increasing cost of academic journals, the focus here is on the connection between journal acquisitions and the "production of knowledge," broadly conceived so as to encompass both the education and innovation aspects of "producing knowledge."

[2] The real-world analogues to the exogenous parameter changes that are subsequently interpreted as "policy changes" in the context of this paper's model are described in Magner's (2000) article in the *Chronicle of Higher Education,* the 1998 Association of Research Libraries (ARL) *Membership Meeting Proceedings,* and the ARL website (www.createchange.org/resources) describing new policy initiatives for dealing with journal-price inflation. Among those policy initiatives, a common theme is the attempt to cut the cost of producing journals by moving to electronic (as opposed to paper) distribution. A second, more controversial approach (advocated by former Stanford University President Gerhard Casper, among others) calls on universities to change the criteria for tenure and promotion in order to reduce the incentives for scholars to prioritize quantity over quality in their research. Beyond the cost-cutting and "change the credentialling criteria" approaches (which are analyzed using the model in this paper), there are a number of other innovative policy ideas which, unfortunately, do not neatly fit into the framework of the model. These include temporary (rather than permanent) copyright transfer agreements (Shulenburger 1998), Varian's (1997) vision of a new online review process, the new "review of web-papers" journal-concept being undertaken by the creators of *NotaJournal*, and the activism of economist Ted Bergstrom (2001) in calling for reviewers to refuse working (for free) for journals with high cost/quality ratios. The empirical stylized facts regarding journal-price inflation (and analyses of its possible causes) can be found in McCabe (2002), Bergstrom (2001) (see also http://www.econ.ucsb.edu/ tedb/), Branin and Case (1998), Odlyzko (1998), Sosteric (1997), Adams and Griliches (1996).

in the present which types of research will prove useful in the future. Or the gap in meanings of “quality” may be caused by inefficiencies in the review process, when editorial decisions are based partially on political considerations and not purely on “the merits.” Regardless of its source, the rationale for being interested in the quality-spectrum lies in the potentially harmful consequences of a mis-match between private versus social definitions of “quality.” If quality is measured poorly or distorted by market failures in the academic industry, then policies which compress the quality-spectrum — even if that means re-allocating journal expenditures away from “low-quality” journals into “high-quality” journals (which sounds like it ought to be efficient) — may actually impede rather than accelerate progress in the academic community’s pursuit of socially-useful activities.

This paper demonstrates that seemingly efficient policies, e.g., those that reduce the marginal cost of producing journals, can reduce the size of the quality-spectrum. The link between changes in the quality-spectrum and social welfare has not yet been integrated into the formal analysis and, in this sense, the results should be seen as preliminary. It is hoped, nevertheless, that the quality-cut-off-point model will spark greater consideration of the possibly detrimental effects on “pluralism in the quality domain,” as debates about the efficient distribution of scholarly communication move forward.

1 The Quality-Cut-Off-Point Model of Journal Acquisition

Three categories of inputs in the knowledge-production process K are considered: (1) the stock of journals J owned by an individual university, (2) the level of expenditures on complementary goods and services C, and (3) the average level of knowledge-production across all research universities $\bar{K}$. The last input $\bar{K}$ is included in order to capture the beneficial network externalities that characterize a typical knowledge-diffusion process in the absence of significant barriers, and is taken as given by each individual university.The second category of inputs consists of “complementary expenditures,” a very general category that includes all non-journal university expenditures that contribute to the production of knowledge. With an exogenously given university budget B (determined by state legislators in the case of most public institutions, or by a board of trustees for most private institutions), the complementary expenditures can be re-expressed as $C = B - E$, where E denotes the university’s expenditures on journals.[3]

The first input, labelled J, represents the aggregate quantity of academic journals acquired by the university. The aggregate quantity of journals directly affects the production of innovative research and contributes to the education of students (and perhaps the community surrounding the university). For the purpose of producing knowledge in this sense, it is debatable how best to aggregate a university’s collection of journals. One may presume that high-quality journals are more productive than low-quality journals, and therefore ought to

[3] By putting non-journal expenditures $B - E$ directly into the production function, it is implicit that the prices of non-journal expenditures are stable, so that changes in $B - E$ reflect varying *quantities* of non-journal inputs, rather than changes in the prices of non-journal inputs. Even without this assumption, the model simply requires a modification of the interpretation of “the prices of journals” (introduced below). By the modified interpretation, the price of a journal is a relative price, in units of non-journal expenditures.

receive additional weight in the process of aggregation. By the same token, there are reasons why possessing a high-quality journal may not be as beneficial as holding a low-quality journal. For instance, the contents of a high-quality journal are likely to be discussed more widely, with overlapping coverage at conferences, other high-quality journals, and through less formal channels such as online chat groups. Owning a lower-average-quality journal containing results that are less accessable through alternative media may therefore be more valuable for the researchers and students at a particular university. Another argument along these lines, albeit somewhat cynical, follows from the proposition that truly innovative material is less likely to appear in high-quality journals. This problematizes what is meant by "quality" of a journal. It also serves as a rationale for applying uniform weighting in aggregating journal holdings. This is an important modeling choice and is therefore stated explicitly: in this paper, the production of knowledge depends on a uniformly-weighted aggregation of journal holdings.

One of the key questions, then, is how universities choose J. In order to study how this choice is made, I interviewed a small sample of research librarians, discovering what seems to be a common pattern. When those in charge of deciding which journals to acquire actually make their decisions, an attempt is usually made to first assign individual journals (within a particular field) to categories of relatively uniform quality. Together, these categories form a family of categories, ordered by quality. This is not exactly the same as "ranking journals," since each quality-category has multiple journals in it. After having partitioned the universe of all journals into a family of quality-categories, the university then decides which categories will be chosen from by coming up with a quality-cut-off-point. Simultaneously, the quantity of journals from each quality-category must also be decided. Thus, the choice problem remains fairly high-dimensional, involving both a choice over quality-categories and a choice of quantities demanded from each category.

An interesting aspect of the interview testimony on journal acquisitions, however, is that the choice of quality-categories strongly dominates, in terms of difficulty and importance. In contrast, the within-category choice of quantity is usually regarded as pre-determined, by journal acquistion choices from the past. The multi-dimensional decision-problem of picking which journals to acquire winds up boiling down to picking a quality-cut-off-point below which no journals are acquired, and above which, all journals currently subscribed to are continued.

In order to formalize this stylized account, we consider a continuum of quality-levels, indexed by a, in the unit interval [0,1]. Corresponding to each level of quality a, the symbol $q(a)$ refers to the quantity of journals at that quality-level to be acquired by the university. The pre-determined within-quality-level demand function is given by

$$q(a) = e^{-p(a)/a}, \tag{1}$$

where $p(a)$ is the price of a journal with quality a.[4]

The strong assumptions implied by working with an *a priori* (rather than *derived*) within-category demand function $q(a)$ allow this model to focus on the choice of the quality-cut-off-

[4]The functional form in (1) reflects a moderate degree of within-category price-sensitivity, with price-elasticity $-p(a)/a$, which may be increasing or decreasing depending on the price function $p(a)$. The functional form of $q(a)$ also implies, for fixed $p(a)$, higher demand for journals in a higher-quality categories, i.e., $q(a)$ is increasing in a holding $p(a)$ constant.

point, denoted $\alpha \in [0,1]$. Once decided upon, the quantity $q(a)$ is acquired for all $a \in [\alpha, 1]$, whereas no journals are acquired in the region $[0, \alpha)$. The aggregate quantity of journal holdings is then seen to be a functional of the choice variable α and the price function $p(a)$:

$$J(\alpha) = \int_{\alpha}^{1} e^{-p(a)/a} da. \tag{2}$$

Similarly, total journal expenditures E is a functional of α and the price function $p(a)$:

$$E(\alpha) = \int_{\alpha}^{1} p(a) e^{-p(a)/a} da. \tag{3}$$

Assuming Cobb-Douglas technology with respective journal-, non-journal-, and network-elasticities of production γ, η, and ϕ, the knowledge production function (the university's objective function), written in explicit form, is

$$K(\alpha) = J(\alpha)^{\gamma}(B - E(\alpha))^{\eta} \bar{K}^{\phi}. \tag{4}$$

With the budget constraint $C(\alpha) + E(\alpha) = B$ already imposed through the substitution of $B - E(\alpha)$ for $C(\alpha)$, the university's problem amounts to a simple (unconstrained) optimization problem in α, with first-order condition (after simplification):[5]

$$\frac{\eta}{\gamma} p(\alpha) J(\alpha) + E(\alpha) = B. \tag{5}$$

The second-order condition is not satisfied for all price functions, and must therefore be checked on a case-by-case basis, along with the corner solutions "acquire all journals" ($\alpha = 0$) and "acquire no journals" ($\alpha = 1$).

1.1 Examples

Before closing the model by deriving the supply of journals, some examples are provided which relate different price functions $p(a)$ to different optimal choices of α. With $p(a) = a$, the quantity of and expendtitures on journals are:

$$J(\alpha) = \int_{\alpha}^{1} e^{-1} da = e^{-1}(1-\alpha), \quad \text{and} \quad E(\alpha) = \int_{\alpha}^{1} a e^{-1} da = \frac{1}{2} e^{-1}(1-\alpha^2).$$

With the parameters $\frac{\eta}{\gamma} = 1$ and $B = 0.1$, the first-order condition is

$$a \frac{1}{2} e^{-1}(1-\alpha) + e^{-1}(1-\alpha^2) = 0.1,$$

which has the unique (in the unit interval) solution $\alpha = 0.846$. Corresponding to these parameter values and the price function $p(a) = a$, the knowledge-production function (in

[5]Taking the logarithm of the objective function and setting the first derivative to zero produces the equation

$$\gamma J'(\alpha)/J(\alpha) - \eta E'(\alpha)/(B - E(\alpha) = 0.$$

Equation (5) results after substituting $J'(\alpha) = -e^{p(\alpha)/\alpha}$ and $E'(\alpha) = -p(\alpha)e^{p(\alpha)/\alpha}$, and canceling the term $-e^{p(\alpha)/\alpha}$.

log scale) is presented, as a function of α, in Figure 1. By inspection and by numerical evaluation of the second derivative of knowledge at the maximizer, the objective function is seen to be concave, with unique global maximizer $\alpha = 0.846$.

For the convex price function $p(a) = a^2$, concave price function $p(a) = a^{0.5}$, and constant price function $p(a) = 1$, a unique global maximizer continues to exist.[6] The knowledge-production functions for these (and other) price functions are depicted in Figure 1. The maximizers corresponding to different price functions are listed in Table 1. The model's potential for generating non-concave regions of the objective function is demonstrated by the knowledge-production function corresponding to the price function $p(a) = 1.6 + a$ in Figure 1.

1.2 Profit-Maximizing Journal Producers

The owner of a for-profit journal at quality-level a is assumed to take the market demand function $Iq(a) = Ie^{-p(a)/a}$ as given (I is the number of research universities), choosing $p(a)$ to maximize profit. Assuming a linear cost function with fixed cost f and marginal cost c, the firm's profit function can be written

$$Ie^{-p(a)/a}(p(a) - c) - f. \tag{6}$$

The profit-maximizing price $p(a)$ for a journal of quality a is therefore

$$p(a) = c + a. \tag{7}$$

Under the specialized assumptions of this model, profit-maximizing firms charge universities marginal cost plus a markup equal to journal quality.

1.3 Equilibrium

For every level of quality a, the price of journals is $c + a$ and market demand for journals is $Iq(a) = Ie^{-p(a)/a}$. It is now possible to endogenize the equilibrium quality-threshold α. One simply inserts $p(a) = c + a$ into the university's first-order condition and computes α to solve

$$\frac{\eta}{\gamma}(c + \alpha) \int_{\alpha}^{1} e^{-(c+a)/a} da + \int_{\alpha}^{1} (c + a) e^{-(c+a)/a} da = B. \tag{8}$$

By implicitly differentiating (8) with respect to the exogenous parameters c, B, and $\frac{\eta}{\gamma}$, a number of policy proposals aimed at dealing with rising journal prices can be analyzed.

2 The Effects of Exogenous Changes on the Quality-Spectrum

It can be verified that, whenever the second-order condition is satisfied ($\frac{d^2K}{d\alpha^2} < 0$), the expression $[\frac{\eta}{\gamma}(p'(\alpha)J + pJ') + E']$, which appears in the denominator of equations (9), (10),

[6] The integrals that define $J(\alpha)$ and $E(\alpha)$ do not always have a closed-form expression, as in the case of $p(a) = 1$ where $J(\alpha) = E(\alpha) = \int_{\alpha}^{1} e^{-1/a} da$. These cases are handled easily, however, by numerical methods, both in solving the first-order condition and in checking the second-order condition.

and (11), is negative. With this result, and the substitutions

$$p(a) = c{+}a,\ J' = -e^{-(1+c/\alpha)},\ E' = -(c{+}\alpha)e^{-(1+c/\alpha)},\ \frac{\partial J}{\partial c} = -\int_\alpha^1 \frac{1}{a} e^{-(1+c/a)} da,\ \text{and}\ \frac{\partial E}{\partial c} = c\frac{dJ}{dc},$$

the following inequalities must hold:

$$\frac{d\alpha}{dc} = -\frac{\frac{\eta}{\gamma}J - (\frac{\eta}{\gamma}(c+\alpha)+c)\int_\alpha^1 \frac{1}{a}e^{-(1+c/a)}da}{\frac{\eta}{\gamma}J - (\frac{\eta}{\gamma}+1)(c+\alpha)e^{-(1+c/\alpha)}} < 0 \tag{9}$$

$$\frac{d\alpha}{dB} = \frac{1}{\frac{\eta}{\gamma}J - (\frac{\eta}{\gamma}+1)(c+\alpha)e^{-(1+c/\alpha)}} < 0 \tag{10}$$

$$\frac{d\alpha}{d(\frac{\eta}{\gamma})} = -\frac{(c+\alpha)J}{\frac{\eta}{\gamma}J - (\frac{\eta}{\gamma}+1)(c+\alpha)e^{-(1+c/\alpha)}} > 0. \tag{11}$$

Equation (9) makes the counterintuitive point that reductions in the (marginal) cost of producing journals can actually reduce the quality-spectrum, measured in this model by the size of the interval $[\alpha, 1]$, i.e., $1 - \alpha$. By reducing the cost of producing journals, the quality threshold α rises, meaning that the quality-spectrum $1 - \alpha$ shrinks. Falling journal costs lead universities to re-allocate journal expenditures away from low-quality journals and into deeper coverage of high-quality journals.

It is not obvious that a shift in the composition of university journal holdings which reduces the number of "low-quality" journals is socially beneficial. Whether this outcome is seen as good or bad is, indeed, a subjective issue pointing to the deeper problem of defining what "quality" in the context of academic journals actually means. So long as one maintains confidence in quality-ranking schemes, i.e., accepting the notion that there exist objective criteria which succeed in ordering the universe of journals from best to worst, then it is straightforward to conclude that quality-spectrum compression is good. When the quality index a is a true indicator (or a highly correlated proxy) of objective quality, then society is best served by focusing on high-quality journals and pursuing policies (e.g., reducing c) which serve that end.

On the other hand, the wider the gap between the quality index (a) used by librarians and academics, and "objective quality," the greater the probability that quality-spectrum compression leads to journal collections missing worthwhile material. This existence of this gap provides a rationale for wanting the quality spectrum $1 - \alpha$ to be large. I.e., the uncertainty that makes it difficult to precisely measure the quality of new research leads to an argument in favor of pluralism with respect to quality.

The relevant question lies in determining how effective high-quality journals are at devoting attention to the research that best serves society's interests. If high-quality journals can in fact sustain their high quality in the objective sense of minimizing the gap between what is currently thought to be "high quality" and what ultimately turns out to be "high quality," then society's interest may be served by relying solely on them. If, however, high-quality journals take part in *producing* the meaning of "quality," they may fall victim to self-reinforcing practices that limit rather than augment convergence toward objectively high-quality research. A concentration in the quality spectrum may be more prone to "premature lock-in" and cyclic rather than progressive patterns in the evolution of thought.

In addition to $\frac{d\alpha}{dc} < 0$, the model generates two other comparative static results, contained in equations (10) and (11), each corresponding to distinct policy approaches to dealing with journal-price inflation. The model tells us that, by increasing the university budget B, the quality-spectrum $1-\alpha$ will rise, just as one would anticipate. In dealing with rapid journal-price inflation, simply increasing the university's overall budget has indeed been the de facto policy at a number of research universities with endowment funds large enough to keep up with annual double-digit percentage increases in the cost of journal subscriptions. While this may reflect a savvy strategic approach for establishing a better relative position or "market share" within the world of knowledge-production, competing in this manner amounts to a "library-spending arms race," which has dubious efficiency implications.

Equation (11) states that a shift in the knowledge-production function by which non-journal expenditures become more productive relative to journal holdings winds up increasing the quality-cut-off-point α, thereby reducing the quality spectrum $1-\alpha$. When $\frac{\eta}{\gamma}$ goes up, the optimal mix of inputs required to produce any level of knowledge shifts. At the pre-adjustment levels of journal and non-journal expenditures, the marginal product of journal holdings is too low, and journal holdings must therefore be reduced in order for marginal products of the two inputs to match. Because quantity demanded $q(a)$ (at quality level a) does not respond to $\frac{\eta}{\gamma}$, this re-allocation of inputs (away from journals and into non-journal expenditures) can only be accomplished by raising α, i.e., by reducing breadth.

3 Conclusion

In its focus on the quality-spectrum $(1-\alpha)$, the model in this paper cautions that policies pushing for a switch to electronic journals, although infused with sincere optimism about the capacity of new cost-reducing technology to broaden the dissemination of scholarly communication, may wind up narrowing the field in certain respects. Evaluating the social-welfare consequences of that kind of narrowing ultimately will require further investigation into the meaning of journal "quality," and perhaps empirical analyses of the role "low-quality" journals have played in producing big ideas, i.e., important innovations which were introduced in less prestigious journals and only subsequently reached the mainstream.

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Table 1: Various Price Functions and the Corresponding Global Maximizers α^*

$p(a)$	α^*
a	0.846
a^2	0.853
1	0.692
$a^{0.5}$	0.838
$-a\log(a)$	0.850
$1.6 + a$	0.467

The parameter values used in these calculations are: $\frac{\eta}{\gamma} = 1$ and $B = 0.1$.

Figure 1: Knowledge-Production Functions for Various Price Functions