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An auction market for journal articles

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Abstract We recommend that an auction market replace the current system for submitting academic papers and show a strict Pareto-improvement in equilibrium. Besides the benefit of speed, this mechanism increases the average quality of articles and journals and rewards editors and referees for their effort. The "academic dollar" proceeds from papers sold at auction go to authors, editors and referees of *cited* articles. This nonpecuniary income indicates the academic impact of an article—facilitating decisions on tenure and promotion. This auction market does not require more work of editors.

Keywords Academic journals · Academic productivity · Market design

JEL Classification A11 · D02 · D44

> The Manuscript Clearing House ... would reduce the social cost of information to editors, authors and the subscribing public thereby generating considerable efficiency in the production and consumption of scholarly output. By promoting competitive bidding for manuscripts, it would equalize returns to scholarly output across ranks, improve the efficiency of the academic job market and tend to reduce alleged discrimination by journals. [...] Editors would have far more information about the papers available on the market, reducing duplication in publication, double reviewing and delay in collating related papers.—Havrilesky (1975)

Many academics wish the Current Publishing System (CPS) worked better (Ellison 2002a, 2002b; Colander and Plum 2004), and the need to reform is growing as pressure from different sources increases. Junior academics need a working system to validate their academic production; senior academics may abandon a dysfunctional one (Oswald 2006; Ellison 2007).

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Some reforms address speed: The Berkeley Electronic Press urges reviewers to work faster (time-to-decision averaged 43 days in 2007). The Social Science Research Network sidesteps reviewers, allowing authors to instantly distribute preprints. Others change the reviewer's role: Open source peer review allows anyone to comment (Zamiska 2006); Tsang and Frey (2006) suggest an "As-Is Review," i.e., editors accept or reject based on referee comments, but authors choose which revisions to make. Each of these ideas fails to address the main problem: Giving adequate incentives to referees who must expend effort to understand a paper well enough to improve it.

We propose auctions—with revenue sharing—to fix incentives. Although we worked out "our" auction idea before discovering Havrilesky's article cited above, we are pleased to find this precedent. Our version of a competitive market differs from Havrilesky's in its treatment of currency (we do not use cash), payments (authors, editors and referees of *cited* articles are paid; not the author of the auctioned paper), and the formalized treatment of incentives (see the Appendix). We are also presenting this idea at a time of unprecedented pressure on authors (for publication) and journals (for audience), a time when change is a relatively attractive option.

The Auction Market for Journal Articles (AMJA) works as follows: In period zero, the author writes, markets and submits his paper to the AMJA auction server. In period one, editors screen and value papers. In period two, editors bid for papers. Winning bids—in "academic dollars" or A$—go to the authors, editors and referees of articles *cited* in auctioned papers. In period three, referees review papers. Editors decide to accept or reject papers in period four. (We call accepted papers "articles" after they are published.)

Since papers do not generate A$ income unless they are cited, authors have an *additional* incentive to write well. Since referees and editors share A$, they have incentives to improve papers—rather than reject them—and to speed up the review process.

After a paper is published as an article, citation revenue is an accurate measure of its value: A$ revenue rises in the number of citations it receives, the "quality" of the citing papers (as reflected in their auction prices), and the uniqueness of the article—if similar papers are also cited, all papers receive lower citation revenue. It is a simple step to sum an individual's A$ income (from work as author, referee, and/or editor) to get an accurate signal of academic productivity. This signal could facilitate decisions on tenure, promotion, grants and so on. Since A$ income can map to income, prestige or some other incentive, overall outcomes will improve. For example, experienced referees could work full time on improving others' work (a useful division of labor that raises overall productivity) in exchange for A$ income that can be used to gain career benefits; see Sects. 3.2 and 3.3 for more on A$.

The AMJA is new only because it applies existing ideas in a novel way. Readers familiar with auctions and "markets" for books and movies will see familiar parallels. Auctions are useful for the discovery of consumers' valuations of innovative products (experience goods) and allocate the good to the bidder with the highest willingness-to-pay (WTP). This is efficient. Currently authors of books or producers of movies can already auction their output among publishers/distributors. The AMJA makes sure the editor with the highest WTP, who thinks that this paper will generate the highest citation revenue in his journal (given that he publishes it), obtains the right of publication. The author and referee of the paper also benefit, via citation revenue.

In the next section, we describe the pros and cons of the CPS. In Sect. 2, we describe the AMJA, compare it to the CPS, and explain how the AMJA results in faster publication of better articles (the Appendix contains a game theoretical treatment of Sect. 2). In Sect. 3, we discuss some aspects of the AMJA not included explicitly in the model (valuing academic output, bidding errors, citation gaming, implementation and comparison to law reviews) and explain how editors need not spend more time acquiring papers under the AMJA.

1 Problems in the current publishing system

> Science demands recognition of the fact that exclusive review procedures promulgated by editors work to their and to the referees' decided advantage, not to that of potential authors. The basis for this policy is more one of convenience, power, and control than ethics.—Szenberg (1994)

> An editor's job is triage, but he is unpopular since he rejects 75 percent of the submissions, sends papers for review to people who are too busy and then badgers those reviewers.—Pressman (2005)

> ... an active discussion among economists could reveal a lot about whether the current system maximizes the utility of those involved or whether an alternate system might make economists' lives more enjoyable and research more productive.—Ellison (2002b, p. 990)

In the CPS, an author chooses and submits his paper to one journal. This choice matters: Shoot too high and suffer delay before rejection;[1] shoot too low and waste an opportunity to publish well (Oster 1980). According to Judge et al. (2007), the single most important factor determining an article's popularity is not how well it is written, who the author is, or the originality of the idea—it is the prestige of the journal publishing it. If true, authors are right to worry about appropriate placement. Unfortunately, bias in favor of their own brilliance ensures they shoot too high more often than too low, wasting everyone's time.

The editor receives papers pushed by authors. If the editor does not "desk reject" the paper, he chooses one or more referees to review it. Their reviews help the editor decide to accept or reject the paper. Although all parties to the process are trying to do the right thing, editors and referees make mistakes in rejection (or acceptance).[2] These mistakes arise from the characteristics and incentives of the CPS: Authors push papers at editors, who have a temporary monopoly on review by referees who receive little credit for their work.[3]

Let us look at the CPS from the perspectives of each actor, concentrating on the main problem each faces.[4]

Readers are unhappy because the CPS is too slow—recent publications do not reflect state-of-the-art research[5]—and the CPS system of matching papers to journals by quality is too inaccurate: Although all articles in a given journal may be good, not all good articles are in that journal—readers have to search elsewhere or wait for the articles to appear (Starbuck 2005; Chow et al. 2006; Oswald 2007). On the other hand, readers are happy because journals filter and rank articles from a much larger pool of papers—improving them (presumably) before publication.

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[1] The average wait for rejection is eight months; 30% of articles accepted for publication had been rejected previously by other journals (Hamermesh 1994).

[2] Gans and Shepherd (1994) reported how (now) famous economists could not get their seminal articles published.

[3] Ironically, one of the most widely cited articles on deadweight losses from monopoly—Tullock (1967)—ran into this problem before it was finally published in *Economic Inquiry*. Tullock's discussion of additional, non-quantifiable welfare losses from rent seeking and lobbying is relevant to the monopoly dynamics of the CPS.

[4] We ignore other parties (e.g., publishers and university administrators) to concentrate on the central players in academic publishing.

[5] Publication delay may explain the increasing number and cost of conferences: conference value rises with delay.

Authors are unhappy because slow publishing delays decisions on tenure & precedence and the debate, use & dispersion of their ideas: Submitting to the wrong journal increases delay. On the other hand, authors like the control and choice they have in the CPS. They push their papers to the journals they want. They also like getting "free" review services, although this is a negative externality for referees and editors.[6]

Editors are unhappy because authors push papers at them: They choose neither the quality nor volume of incoming papers, reject authors, affect others' careers, struggle with referees, are paid little, and sometimes doubt the sincerity of those who claim to be friends. On the other hand, power and prestige benefit editors' own research and careers.

Referees are unhappy because they work for "free:" Their reputation does not improve because their work is usually anonymous; editors push them; and they focus on rejecting—not improving—papers. On the other hand, referees are happy because they receive "credits" from editors for future (favorable) treatment of their own work, "give back" to the community; and get access to insider information.

The greatest weakness of the CPS are the poor incentives referees face, which lead them to choose sub-optimal effort.[7] Referees delay and/or avoid work, argue with each other and fail to understand value (Szenberg 1994; Starbuck 2003; Seidl et al. 2005).[8] They reject original, significant works that conflict with conventional wisdom and favor papers that echo their own work (Armstrong 1997, 2002). Referee reviews have a low or negative correlation with subsequent citations; referees often miss the big picture, and over three-quarters of their requested changes are based on "whim, bias or personal preference" (Armstrong 2002; Starbuck 2005). If there is one thing to fix, it is referee incentives. The AMJA does.

2 The auction market for journal articles

In the last section, we introduced the four parties involved in the publication process. In our formal model, we characterize each party by a utility function that reflects their main costs and benefits from publication. For a game theoretical treatment of the AMJA, see the Appendix. In this section, we describe their preferences, the AMJA structure, dynamics and equilibrium.

Readers value article quality and publication speed. Since searching for good articles is costly, they look for high quality articles in high quality journals. Because readers determine the subsequent popularity of articles (through downloads and/or citations), they bring discipline to the system—punishing journals for substandard articles and rewarding journals that deliver quality above expectations. Authors benefit from publishing high quality papers, quickly. Before authors can realize the benefits of publication, they must exert effort in writing and marketing their papers to journals, so editors can become aware of the existence of their paper. Editors care about the average quality of articles in their journals, but quality will only rise if they exert effort in making a preliminary review of appropriate papers, choosing referees for papers that survive this review, and preparing papers for publication. Referees review papers so they can improve their chances of publishing in the same journals,

[6] Submission is not always free. Some journals have submission charges and/or require referee reports.

[7] Frey (2003) argues that referees have little incentive to improve papers; he suggests that editors accept/reject a paper before referees suggest improvements—as in the AMJA mechanism.

[8] Garcia-Berthou and Alcaraz (2004) found statistical errors in 38% of the articles they sampled in *Nature* and the *British Medical Journal*. In 4% of the cases, "the conclusion would change from significant to non-significant" [p. 3].

as authors. They are willing to exert effort in judging and improving a paper for this benefit. We also assume that greater effort increases publication speed.

Thus, we see that readers want referees to work harder (improving quality and speed), that authors and editors want to match on quality, and that referees play a key role in improving matching speed and quality. These incentives are present in the CPS. The AMJA adds an incentive—A$ revenue to authors, editors and referees—that delivers a Pareto-improved result over the CPS. The AMJA's benefits come with a cost—authors pay a submission fee to cover the operating costs of the auction server.

2.1 The AMJA game

In the AMJA, authors write papers, market them to editors, and post them for auction. Editors bid Academic Dollars (A$) for papers and assign "purchases" to referees.[9] Referees put in effort to review and *improve*—not reject—papers. Readers read and cite articles (published papers) in their own work. When the papers of those readers (now authors) are later auctioned, A$ are redistributed to authors, editors and referees of *cited* articles as a reward for quality. Figure 1 displays the flow of a paper and A$.

For example, Paper One is auctioned for 100A$. Since it cites ten older articles, the authors, editors and referees of each cited article divide 10A$. When Paper Two—citing Paper (now Article) One and 19 others—sells for 120A$, Article One's author, editor and referee split 6A$ according to their prior agreements. Section 3.3 discusses A$ circulation.

2.2 Analysis of the AMJA game

This section summarizes Sect. A.4, which analyzes the game by backward induction. Since the final decision of the editor is nonstrategic—he simply chooses to publish the best papers he has optioned on the auction market after referees have improved them—we start with the referee's optimization problem in the third (penultimate) period. In this period, the referee decides how much effort to put into improving the paper's quality. Without specifying the magnitude of that effort, we know that it will be greater than the effort exerted in the CPS because the AMJA referee receives additional compensation (A$) in proportion to the quality, i.e., future A$ revenue the published article receives.[10]

In the second period, the editor bids for papers. Because the AMJA is set up as a second-price, sealed-bid auction (all bids are anonymized to be unique), participants cannot behave strategically. He therefore bids according to his private value that depends on the cost of finding a referee, the probability that the paper will turn into an article, the article's expected revenue to his journal, and the editor's share of those revenues. Before bidding in period two, the editor chooses the papers he preliminarily screens in period one. He bids on all papers for which he finds his valuation to be positive. Before the first period, the author decides

[9] Throughout this article, we say that papers are purchased, optioned, and/or won at auction. It is more accurate to say that winning bidders in the AMJA receive an exclusive, temporary option to consider a paper for publication. Publication is not required, and ownership still resides with the author.

[10] Will explicit referee incentives in the AMJA crowd out implicit incentives responsible for current levels of referee effort? Not exactly. AMJA referees are rewarded explicitly in A$ (on top of the current good feeling from "service to society"), not cash. Since A$ act as tokens (or quasi-medals), they reinforce the "service" reward. On the other hand, higher A$ may be positively correlated with higher real income (e.g., a better job), which result in a second order loss of intrinsic motivation. The degree with which A$ income adds to the existing chances of getting a better job as a referee under the CPS (potentially lowering implicit motivation) compared to its augmentation of explicit incentives is hard to predict but probably small enough to ignore.

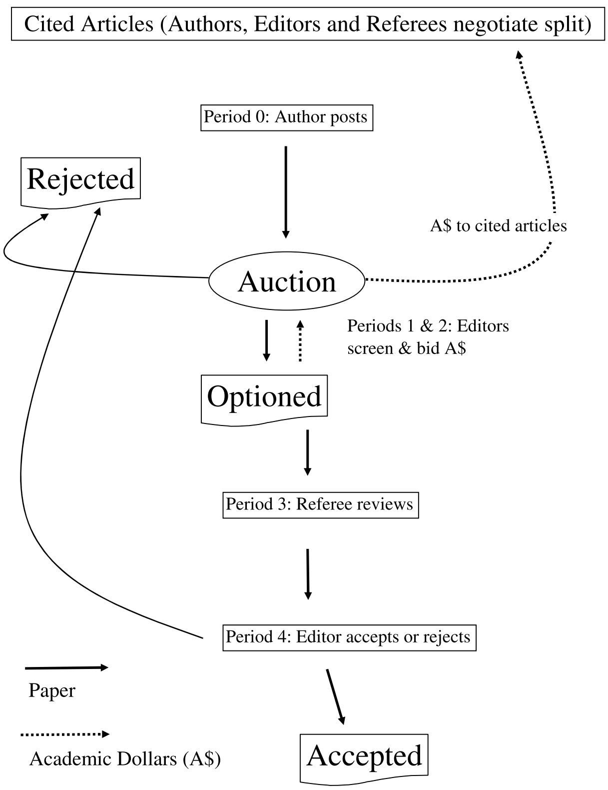

Fig. 1 Market structure from auction to publication. In Period 2, A$ auction proceeds go to prior *cited* articles. The auctioned paper receives revenue after publication, when papers citing it (as an article) are themselves auctioned. Rejected papers go back to the author

how much effort to put into writing and marketing his paper, where marketing is necessary to increase the probability that the paper is known to editors when submitted to the auction server.

2.3 Equilibrium and Pareto-optimality

In Sect. A.5, we show that the additional explicit incentives of the AMJA system induce referees to put more effort into improving papers, editors to pull more papers for preliminary review (which frees other papers from the idleness common in the CPS), and authors to put more effort into papers' quality and marketing. Taken together, these actions will increase the quality of journals and reduce publication delay—for the benefit of all. We also show that all players in the AMJA are better off on average—given that the submission fee to the auction server is sufficiently low. In other words, the AMJA-equilibrium is strictly Pareto-superior to the CPS-equilibrium.

3 Discussion

The culture of academics is reasonably efficient at enforcing norms of integrity, hard work and truth, but it takes more than culture to overcome weak incentives for referees, imperfect matching of papers to journals, monopolistic editorial controls, and imperfect measurement of output. In *The Organization of Inquiry* (1966), Gordon Tullock (2005/1966) discusses the scholarly "ecosystem" that encourages, protects and disciplines researchers facing mixed incentives and vague notions of success. The AMJA-mechanism contributes to that discourse and sharpens—via auctions and A$ distribution—the incentives for and quantification of useful research. Tullock thought readers to be best positioned to judge the value of articles; he was less excited about the responsibility of editors as gatekeepers to publication. The AMJA improves on the CPS by increasing competition among editors—weakening the gatekeeper effect—and sharpening reader opinions on value—via citations. He also worried that anonymous referees would have little reason to spend time improving papers, perhaps passing judgement too quickly when the risk of being confronted with mistakes—like the reward for success—was small. Finally, he worried that editors would economize on the time they spent evaluating papers and the editorial risks they took [pp. 115–122]. Since referees and editors in the AMJA receive greater benefits when an article is successful than they do in the CPS, we believe that the AMJA does a better job at addressing these problems. In this section, we discuss these themes and expand upon the results of the previous section, which, in turn, summarizes the detailed analysis in the Appendix.

3.1 The editor's workload

Although readers of this article may be excited by the prospect of faster publication of better articles or referees working to improve—rather than reject—their papers, these aspects are immaterial relative to the editor's question: "Will I have to work more in an AMJA system?"

For readers of this journal, this question will be familiar. One of the fundamental principles of public choice economics is that people do their jobs not just as professionals but also as individuals, sometimes weighing personal interests above professional ideals. In fact, we believe that the AMJA will make an editor's job easier without necessarily increasing his workload.

The work of editors in the CPS has changed less than it could have in the last decades. Specifically, editors are making much less use of information technology (IT) than optimal. In the AMJA system, editors can use IT to filter for a preliminary set of papers (named L in the model) to review. The key word is heuristics. Articles are now classified in many dimensions, e.g. JEL codes, political science codes, keywords, cited articles, cited authors, methodology, length, and so on. All of these dimensions can be searched with algorithms; see Econlit or comparable databases. Most working papers are now formatted in the same way, allowing them to be classified in dimensions that match academic standards. AMJA editors can take advantage of this development by specifying search criteria in any combination of dimensions in their profile on the auction server. They would only receive email notifications when papers submitted to the auction server met their prespecified requirements, akin to an upgraded version of today's SSRN abstract newsletters. By restricting search criteria, editors can indirectly limit the number of papers they see, even while improving the match to their preferences. In contrast, the papers received under the CPS cover a much broader set of topics. Thus, with equal effort an AMJA editor spends less time than a CPS editor on papers that do not interest him.

Apart from this technological improvement, the AMJA makes the editor's job easier by replacing the current push system with a pull system.[11] Say, for example, that a journal receives 500 submissions per year and has to narrow these submissions down to 100 papers

[11] Hagel and Brown (2005) note the efficiency of pull models in an environment of uncertainty; Blois (2000) states that customer pull is more efficient when suppliers market directly to customers (not via intermediaries). This case exists in the AMJA, where authors "sell" to editors/journals, not readers.

(top-ranked journals reject more than 90% of submissions). The editors need to sort and filter the papers into piles—desk rejects, send to referees, find referees, and so on—and somehow throw out 400 papers. Referees know that editors need to reject many papers, so they look for defects. In the end, the editor is left with a pile of papers that are not bad enough to reject—and those are published. Let us observe (without veering into psychology) that this process is much more about unwanted, flawed, rejected papers than wanted, improved, accepted papers.

Now consider the AMJA, where editors pull papers to themselves. As with eBay, papers are "won," and that positive message permeates the AMJA process. Editors participating in auctions get to choose which papers to see, how many papers to see, which papers have higher bids, and much else. Instead of choosing the "least worst" among papers pushed at him, an editor chooses the best papers he sees. To cater to editors' needs, AMJA authors will make their papers more "accessible"—via clearer abstracts, better JEL and keyword choices, and so on—knowing that editors are using these heuristics.

Can we prove that the AMJA need not increase an editor's workload? Yes. We can reproduce the current push system within the AMJA by allowing authors to "handicap" journals in order of their preference. An editor could then pull only those papers that give his journal the highest handicap and bid on them. He would have to compete with others, but such competition is more likely to be helpful (via price signals) than harmful (losing a paper).

Since all editors see all papers simultaneously and bid for those they value, the AMJA places papers more quickly and accurately. Although editors now have to fight for papers they previously got for "free," they also have a chance to get others' papers. Editors can even assemble special topic issues by emptying the market of all applicable papers.

3.2 Valuing academic output

The AMJA quantifies academic output through A$ income, and academics need an accurate measure now more than ever. Long ago, decisions on professional advancement depended on subjective factors. These were replaced over time by "objective" factors such as publication or citation counts. As publication has grown more important, the number of submitted papers has increased, leading—in turn—to a greater supply of journals offering publication spaces.[12] Far from fixing the problem, the multiplication of titles has made measurement (and professional decisions) more difficult. Neither tenure candidates nor committees are happy with current evaluation methods (Varian 1997); they need a simple indicator.

In the CPS, academic departments may multiply articles (or pages) by the "rank" of the publishing journal. The department may define rank (inviting provincial bias) or use ISI's "Impact Factor" (inviting ISI's bias).[13] A more accurate method multiplies citations of an

[12] When publishers (both for-profit and non-profit) realized they could issue more journals without lowering prices—since journals are complements and not substitutes—the number of journals exploded from about 120 in 1980 to almost 300 in 2000 (Bergstrom and Bergstrom 2001; Plasmeijer 2002). EconLit lists over 1,100 at http://www.econlit.org/journal_list.html—using a more inclusive definition. Bergstrom (2001) claims that many new journals deliver little value.

[13] "The impact factor of a journal is calculated by dividing the number of current year citations to the source items published in that journal during the previous two years. Example: A = total cites in 1992 B = 1992 cites to articles published in 1990–91 (this is a subset of A) C = number of articles published in 1990–91 D = B/C = 1992 impact factor" (Garfield 1994); see Kalaitzidakis et al. (2003) for another method. Thompson ISI has a monopoly on citation tracking, mixes authors with the same first initials, is sloppy about journal inclusion, fails to control for different journal formats, and introduces within-journal citation bias (Klein and Chiang 2004).

author's articles times the impact factor of the journals where citing articles appear, i.e., the value of each article (i) depends on the number of citing articles and the impact factor of the journals (j) in which those articles appear. Thus, total value of an academic's work is $\sum_i \sum_j \mathit{Impact\ Factor}_j$. The main problem with this metric is the bias within ISI's impact factor. An additional problem is the assumption that all articles in a journal have the same quality as the journal's Impact Factor. For example, a citation from an excellent article in a "bad" journal counts for less than a citation by a terrible article in a "good" journal. This method gives *prima facie* inaccurate measures of value (Chow et al. 2006; Ellison 2007; Oswald 2007). Oswald (2006) notes growing reliance on citations is increasing the incentive for manipulation.[14]

Under the AMJA, an academic's output is the sum of his A$ earnings as an author, editor and/or referee. The value of a journal is the sum of A$ earnings to articles that appear in that journal. Since A$ will vary with an article's *actual* academic quality, these measures are more accurate. Thus, the impact of an article is determined endogenously in the AMJA (via its A$ revenue), while it is exogenous to participants in ISI's system.

3.3 A$ circulation

The AMJA uses nonpecuniary Academic Dollars (A$)—not a liquid currency like US$. After each auction, A$ are allocated to the authors, editors and referees of *cited* articles in proportion to their prior agreements. (The initial allocation of A$ may be in proportion to subscribers, citations, impact factor, or some other variable.)

It is important to consider what happens to the A$ that pass from editors buying papers to the authors, editors and referees of cited articles. Although receiving editors can use the A$ to bid for new papers, authors and referees (assuming they are not also editors) cannot spend their A$. We suggest that authors and referees be obliged to reassign their A$ to *any editor(s) they choose* within, say, one year.[15] Although some may choose to sell their A$ for cash, we think a significant number will enjoy the opportunity to reward their favorite editors/journals.

Redistribution will strengthen good editors/journals and support competition to serve the needs of authors and referees—with more votes coming from those with more success. A$ reallocation gives journals the incentive to increase their differentiation and quality, lowering search costs. If the journal's subscription price was "too high" relative to its A$ revenue, it would lose readers and citations. Journals that charged "too little" could choose between increasing price or building even higher readership.

Why would a top journal support the AMJA and take the risk of a change in its ranking? First, top journals would receive quite a bit of A$ income from citation revenue. Second, many top journals are non-profits run by academic societies that (on paper) serve the interests of the greater community. Third, journals that do not support the AMJA risk losing access to new papers; see Sect. 3.7. Fourth, those in power at these journals would benefit (as authors) from the AMJA, and they may decide to enroll the journal in the AMJA.

[14] Some publishers have begun measuring an article's impact by its download count—a measure that's superior to impact factors but which omits the implicit "download" that occurs when someone reads the printed article in its journal. Measurement by download can complement measurement by A$, which is both forward-looking (the price of a paper at auction anticipates future revenue) and backward looking (A$ revenue comes when the article is cited by a paper sold at auction).

[15] Interestingly, an editor's limited supply of A$ might limit the practice of excessive "banking," i.e., accepting so many papers that "the time lag from acceptance to publication [rises] to 30 months or even three years" Dunleavy (2003, pp. 231–2).

In the CPS, it only takes money and an editorial board to start a new journal, and publishers have started many new journals. Although these journals are profitable for the publishers, they have fragmented the market into niches that deliver few benefits to readers, dubious benefits to authors, and budget problems to research libraries (Bergstrom and Bergstrom 2001, 2004).

Because it would be difficult to start a journal without A$ in the AMJA, "hot" money publishers would be thwarted. Entry would instead occur when authors/referees pooled their A$ to support a new journal. (Minority and heterodox editors could benefit from a *relatively* loyal constituency.)

Exit occurs when a journal fails to garner A$ support from authors/referees. Both for-profit and non-profit journals would need A$ revenues if they are not to fail from "academic unprofitability". Although wealthier journals could buy A$ on a black market—strengthening their bidding power—they would lose power if they did not receive equal A$ revenue.

The fixed supply of A$, reallocation norm and trading costs are likely to limit the importance of cash in an A$ black market. A cash AMJA would suffer from many problems (inflation, hot money entry, high-powered incentives) and offer few—if any—benefits. By using A$, we avoid the problems of high powered-incentives—encouraging cash profits over academic knowledge—and support those who produce value within the publication system (Besley and Ghatak 2005).

3.4 Bidding errors

An editor's desk review assigns values to some papers from a larger set. Errors in establishing these values—due to mistakes in the editor's judgement and/or stochastic elements in eventual, realized demand—means that they vary from the true quality (value). An editor who overestimates a paper's published value as an article is more likely to win a paper by bidding too high and less likely to a paper when his negative error leads him to underestimate a paper's value.

In the CPS, editors benefit from referee comments when considering value.[16] AMJA editors only receive this benefit if they win the paper at auction. Holding all else constant, an editor in the AMJA looking at the same set of papers as the editor in the CPS is more likely to miss a few good ones and accept a few bad ones.

The cost of these mistakes in the AMJA is trivial: The auction price is slightly lower (higher) for papers where the second price bid is under (over) biased. Since the real value of the paper comes from future citations, an inaccurate bid only affects revenue to cited articles.[17] If the average article is cited a number of times, these errors cancel out. For editors, mistakes in over and underbidding will, similarly, balance out if other editors make mistakes at the same rate. An editor who makes too many mistakes exits in the long run. For the author, a mistake means placement in one journal and not another, but this effect will be small when displacement is only a few ranks up/down the journal ladder; it disappears completely if the paper ends up in a horizontally-equivalent journal or if readers read it à la carte.

[16] The CPS advantage comes at a cost, since referees spend time (a negative externality) on all forwarded papers. CPS editor errors matter on the margin, when they desk-reject papers that should have gone to referees.

[17] It is for this reason that we do not have to worry about editors who win "bad" papers. Even if the paper is published—no sure thing—its value depends on the A$ price of subsequent papers that cite it. If these papers point out how bad the article is but are not good themselves, then they will sell for low A$ values, which means that the cited "bad" article will earn little A$ revenue.

In the CPS, the problem of under-estimated value is greater because the wait for rejection is so long. In the AMJA, more eyeballs means fewer Type-I (mistaken acceptance) and Type-II (mistaken rejection) errors; see, e.g., Gans and Shepherd (1994) and Oswald (2007).

3.5 Gaming citations

Although authors face stronger incentives to trade citations ("you cite me, I cite you") in the AMJA, gaming the AMJA is harder because the value of an article depends on the auction prices of citing papers, not just the number of citing papers.[18]

Self-citations would not count in calculating the division of auction revenue for a paper. Citations of friends/colleagues/co-authors would count, since determining the difference between legitimate and undeserved citations would be difficult.[19] Over-citing would decrease if citing authors want to maximize "rewards" to prior contributions they admire; under-citing [plagiarism] would decrease if overlooked authors have a reason (A$) to see their contributions acknowledged. Papers without citations are rare; if one were to sell at auction, the revenue could be distributed to all journals on some *ex ante*, *pro rata* basis.

Works cited that originate outside the auction system (books, unpublished papers, articles from other disciplines, newspapers, and other works) would not receive citation revenue. Authors of these works could track "what if" A$ revenues to understand the opportunity cost of non-participation; AMJA managers could use "what if" A$ to indicate areas where the AMJA should expand with the most benefit.

3.6 Multiple submissions

Although the AMJA resembles the multiple submission system common to law reviews, it differs in important ways, as summarized in Table 1.[20] Pressman (1994) argues against multiple submissions, claiming that publication times are not reduced (because reviews have limited publication space); initial acceptance is delayed (because authors use acceptance by one review to motivate another review); and referee effort lowered (because probability of publication is lower).

Pressman's criticisms do not apply to the AMJA, since editors bid for papers only when they want to fill publication space; authors cannot game editors with a fixed deadline; referees only review papers editors hold exclusively; and referees gain from a paper's success.

3.7 Transition from the CPS

Given that economics journals have the longest publishing delays, the natural place to implement this idea is within economics (Ellison 2002a, p. 998). How do we know it will work?

[18] Thus, an AMJA author who trades citations with other authors gains benefits (A$ income) in direct proportion to the auction prices of those citing papers. Since those prices are exogenous, he is uncertain what is being traded in the shadow market. The likely result is that a researcher capable of writing good/popular papers will only trade citations with researchers whose publication prospects are at least as good as his own, and citation trading will only occur at the same quality level in equilibrium. Such trading may increase absolute A$ income at each "quality cluster" of researchers, but it is unlikely to distort relative income ranking. Hence, the truthful ranking of researchers—the ultimate goal of our publication system—would be accurate.

[19] Although this allowance makes the practice of *quid pro quo* citations possible, that problem already exists in the CPS.

[20] Book publishers and universities handle multiple submissions for books and student applications, respectively. Peters (1976) was the earliest proponent (we found) of multiple submissions for academic journals.

Table 1 Comparing multiple submission to auctions

	Multiple submissions	Auctions
Participation	Push (Mandatory)	Pull (Voluntary)
Competition	Secret	Open
Deadline	None	Predetermined
Allocation	Author's Choice	Highest Bidder
Reviewer Effort	Often Wasted	Rewarded

How can it be better than what we have? These worries, along with the fears that participants would game citation credits and that academics are adverse to being measured—are perhaps over-cautious. Gaming already happens and measurement is already abused (Oswald 2006).

One or more journals might implement a pilot program by pooling submissions and then allowing assistant editors to bid against each other. If a number of journals wanted to begin an AMJA unilaterally, they could return auction revenue to participating journals only. Other journals would have to agree to pool some or all of their submissions in the auction to receive "their share" of citation revenue. The potential for A$ income is highest for journals with stronger catalogs, providing a useful incentive for them to join the AMJA earlier. Early support is especially valuable, since the AMJA has network effects/increasing returns to scale technology.[21]

4 Conclusion

We explore an auction market for journal articles (AMJA) that allows editors to bid for the papers they want, increasing the speed and accuracy of matching papers to journals. Because the AMJA sends A$ revenue to articles cited by auctioned papers, it rewards (and quantifies the contribution of) the authors, editors and referees of those articles. Because editors pull papers toward them in the auction (*contra* the push method in the current publishing system, or CPS) and referees are rewarded when an article they reviewed is cited, the AMJA changes incentives such that referees look for ways to improve—not reject—papers. In the short run, A$ income to authors, referees and editors quantifies their academic contribution. In the long run, the recirculation of A$ (from authors and referees to those editors/journals they prefer) rewards journal quality. Although these benefits are appealing, some readers may worry that they are offset by even greater costs. We show in a formal model that readers, authors, editors and referees gain from moving from the CPS to the AMJA.

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[21] Although we assume a single auction platform (which might create problems of market power or incompetence), multiple platforms could coexist and compete (cf., competing stock exchanges) if A$ and information flowed easily between platforms.

Appendix: A model of the AMJA

We define variables and parameters with all subscripts; in later use, we drop subscripts whenever possible to reduce clutter.

A.1 Induced utility and cost functions

We characterize the induced utility functions of the four parties involved in the publication process by quantifying the main arguments mentioned in Sect. 1. The reader/consumer C values article quality and publication speed, i.e.,

$$v_C = u_C(Q_j, T_j), \tag{1}$$

where the utility of reading articles (u_C) is increasing in the average quality of articles in journal j (Q_j) and decreasing in publication speed of journal j (T_j).

We assume that any competitive publication system—in equilibrium—publishes high quality papers in high reputation journals; this condition solves the reader's asymmetric information problem, i.e., judging the quality of an article before he spends a reasonable amount of time reading it.[22] We also assume that the career prospects of author i depend positively on the reputation of a journal publishing article i; see Judge et al. (2007).[23] Hence, author i prefers to produce a paper with high quality.[24] He also prefers speedy publication, i.e., low T_j. For production of a paper with quality q_i and marketing the paper with effort m_i, the author bears costs of $a_i(q_i, m_i)$, which are convex in both arguments.[25] The author's induced utility is:

$$v_i = u_i(q_i, T_j) - a_i(q_i, m_i). \tag{2}$$

Editor j values the power and prestige of his journal, which is a function of average article quality (Q_j).[26] The editor incurs costs in his job: the cost of preliminary review for submitted papers (s_j), the cost of choosing a referee for papers that survive preliminary review (r_j), and the cost of finalizing papers for publication (f_j). We assume cost functions $s_j(\cdot)$, $r_j(\cdot)$ and $f_j(\cdot)$ are convex in the number of papers at each stage to reflect increasing opportunity costs. Thus, the editor's induced utility function is:

$$v_j = u_j(Q_j) - [s_j(\cdot) + r_j(\cdot) + f_j(\cdot)]. \tag{3}$$

[22] If the reputation ranking of a journal is a rough indicator of the quality of its articles, journals provide a public good to the academic community, i.e., paper preselection and vertical classification. (This is a public good because the journal publishers cannot charge every consumer of the good. All readers can see the table of contents at little or no cost.)

[23] We assume that author and paper are paired only with each other; thus we refer to both with the same subscript i.

[24] Many authors produce high quality for other, extrinsic or intrinsic reasons. Since these reasons complement career goals, we ignore them.

[25] Marketing refers to presenting at conferences or seminars, sending emails, posting to preprint servers and listservs, soliciting reviews from colleagues, and so on Armstrong (2002, p. 78). Costs of quality production and marketing are convex because of increasing opportunity costs, e.g., time away from other work.

[26] We assume that editor and journal are paired only with each other; thus we refer to both with the same subscript j.

Referee R of journal j obtains utility u_R from expected preferential treatment for his next submission to that journal. A referee can invest effort $e \geq \underline{e} > 0$ in judging and improving a paper for a cost represented by the convex function $c_R(e)$. $\underline{e}$ is the minimum effort necessary to deliver a referee report that satisfies the editor; i.e., we assume the editor and referee both know when a report is unsatisfactory. Since one characteristic of report quality is speed, we assume that higher e speeds publication, i.e., $\frac{dT}{de} < 0$. u_R is positively dependent and concave in e. The induced utility of a referee is:

$$\nu_R = u_R(e) - c_R(e). \tag{4}$$

A.2 The auction market for journal articles (AMJA) game

The detailed timing of auctions is as follows:

Period t_0—author writes/markets paper:

Author i writes paper i with quality $q_i \equiv q$ for a cost of $a(q)$ and makes the exogenous decision to post it on the auction server, for an exogenous submission fee of ϕ (in US$, not A$). The author specifies: a reserve price; positive/negative "handicaps" on bids from particular journals in A$, which allow the author to signal specific journals they find (in)appropriate for paper i;[27] the maximum time he will wait for a final acceptance/rejection decision from the editor who wins the paper at auction; a minimum share of future revenues from the article; and whether to remain anonymous.

Since authors specify these five criteria outside of the game, we treat the author's share of future revenues from the article $(1-\alpha)$ and total time from submission of a paper to the auction server to final acceptance/rejection decision (T) as exogenous variables that can be set by the non-strategic organizer of the auction platform.[28] The author decides marketing effort (m), which has a cost of $a(m)$.

Period t_1—editor screens papers:

Editor j of journal j already knows about the set $K_j \equiv K$ papers, where K is a random draw from the much larger set (∞) available on the auction market; see Fig. 2. He decides $|L|$, the number of papers in set $L \subseteq K$, at a cost of $s(|L|)$. In doing so, he learns his willingness to pay $(v_{ij} \equiv v)$ for each of the $|L|$ papers. v depends on the expected revenue of an article

[27] Hence the signalling provided by author self-selection to journal j in the CPS could be imitated—but without the restrictive quality of the CPS signal preventing consideration of paper i at journal $k \neq j$. Unique handicaps would prevent ties among journals.

[28] Diversity in these variables can correct for author and editor/journal heterogeneity. Duration T could be split into a standard duration (T_1) for the auction and a standard duration (T_2) for the editors acceptance/rejection decision. Standardization at the auction server could minimize transaction costs, but flexible Ts allow for various heterogeneities. Auctions should be frequent enough to allow editors several chances to fill each issue of the journal. Although T_2 might exceed the lapse between auctions, we do not consider interauction dependencies here. Also note that AMJA authors only wait until T to learn of acceptance/rejection, unlike in the CPS, where rejection leads to resubmission elsewhere and a longer wait. Even if T lasts as long as the average review period in the CPS, placement under the AMJA is already optimal—in terms of expectations. The author of a paper that receives no bids during T_1 will clearly understand that he needs to invest more in quality and/or marketing—a signal that rejection in the CPS does not produce.

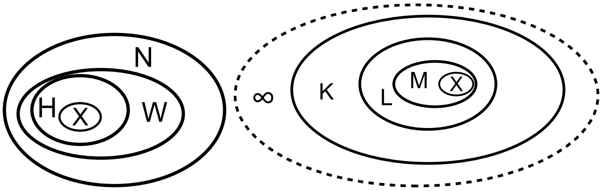

Fig. 2 In the CPS [*left*], editor j makes a preliminary review of subset W in the set of submitted papers N. He sends a subset $H \subseteq W$ to referees for review and accepts $X \subseteq H$. In the AMJA [*right*], each editor has a set K of "known" papers in the much larger set (∞) available on the auction market. He "learns" about (and sets a value on) an endogenous subset L. He wins a subset ($M \subseteq L$) at auctions and sends them to referees and accepts $X \subseteq M$

($\hat{\pi}$), which differs among editors and is drawn from an arbitrary distribution.[29] Let μ denote the probability that the editor's valuation is positive, i.e., $\text{Prob}\{v > 0\} \equiv \mu$.[30] We define that the valuation of an editor for a paper is positive ($v > 0$) if he would publish it given that he has page space. Such a prior is only possible after the editor spends $s(\cdot)$ looking at the paper. Even if such a paper is won at auction, it may not be published if it must compete for space with another paper of higher expected value.

Period t_2—editor bids on papers:

Editor j submits a single bid of $b_{ij} \equiv b$ for each paper in L. A$ bids are not published. This sealed-bid, second-price (Vickrey) auction ends at the pre-specified time after which the highest and the second-highest bids are known. The highest bidder wins and pays the price $p = \hat{b}$, where $\hat{b}$ is the second-highest bid.[31] p is distributed equally among the editors of the articles cited by i (who then split their shares with referees and authors of those articles). Editor j wins a set of papers $M \subseteq L$.[32] He has the right to accept or reject those papers before T ends.

Period t_3—referee reviews paper:

The editor incurs costs $r(|M|)$ to find a referee willing to review the papers he has optioned for a share (β) of future revenues ($\pi_{ij} \equiv \pi$)—should the editor publish the paper.[33] The referee chooses effort e to judge/improve the paper and recommend its acceptance or rejection.

[29] To avoid combinatorial issues we assume that editor $j's$ valuation for paper i does not depend on his valuation for paper $l \neq i$. If an editor wants to bid on related papers (e.g., to publish a one topic issue), he could increase his valuation for paper i by adding a value component to $\hat{\pi}$ that depends on his expected probability of winning the other papers. Alternatively, papers could be bundled at auction.

[30] The probability for positive valuations varies among editors: An editor of a high-quality journal might not want to publish the same paper an editor of a lower-quality journal would; see more about private values on page 396.

[31] These auction rules guarantee maximum anonymity of bidders and bids—and thereby solve the typical problems of auctions with common or affiliated values and sniping; see Sect. A.4 for more details. Without loss of generality we also use $\hat{b}$ to denote the *expected* bid of the second-highest bidder.

[32] Authors pre-specify the bidders they would refuse via Period 0 handicaps.

[33] We assume β, like α, is exogenous. In practice, β may result from a bargaining process that integrates referees' heterogeneous quality and standing.

Period t_4—editor accepts/rejects paper:

We define X as the set of papers accepted for publication in a given issue of journal j and $|X|$ as the exogenously-given number of slots available for articles.[34] Given $|X|$, we define γ as the share of papers the editor can accept out of the $|M|$ won at auction, i.e., $|X| \equiv \gamma|M|$.[35] The editor accepts and finalizes for publication the best $\gamma|M|$ papers at a cost of $f(\gamma|M|)$; he rejects $(1-\gamma)|M|$, which go back to authors who may improve and resubmit them to the auction server. This decision involves no additional effort and therefore no optimization tradeoff.

A.3 Quality production and article revenues

Before we solve the AMJA Game, let us specify $Q_j \equiv Q$, the average quality of *accepted* papers in journal j.[36] Q is a function of the quality of papers authors submit to the auction (q), referee effort (e), and the journal's acceptance rate (γ). As Q is the average quality of papers in X, a subset of ∞, in expectation it depends positively on q_i, a single paper's quality, where $i \in \infty$. As the increased quality of an individual paper translates monotonically into increased average journal quality, we assume that q has a non-convex impact on Q. As a referee's work can increase a paper's final quality and substitute partly for its original quality, e has a similar effect on Q as q.

The editor can rank the $|M|$ papers he has optioned for publication after spending $s(\cdot)$, $r(\cdot)$ and reading referee reports. As long as he chooses to publish the best of those papers, which is in his interest, a lower acceptance rate (γ) results in higher average journal quality, *ceteris paribus*. For simplicity, we assume a linear relation such that γ depends positively on the exogenous number of slots in a given journal issue ($|X|$) and negatively on the number of papers the editor options in the auction market ($|M|$). We assume $|M|$ increases monotonically in $|L|$, the number of papers an editor bids on, because each non-zero bid increases the probability of placing the highest bid for a paper and winning its auction.[37] Formally, we operate with the following Equations:

$$Q = Q(q, e, \gamma(|M|(|L|))) \tag{5}$$

$$\frac{dQ}{dq} > 0; \qquad \frac{d^2Q}{dq^2} \le 0 \tag{6}$$

$$\frac{dQ}{de} > 0; \qquad \frac{d^2Q}{de^2} \le 0 \tag{7}$$

[34] We ignore the fact that papers differ in length.

[35] We will refer to γ also as the "acceptance rate". Note that this rate is different from the CPS acceptance rate, which equals $\frac{|X|}{|N|}$.

[36] This definition allows us to use Q as the "quality of journal j" as well.

[37] If editor j spends s' on paper i and learns that his valuation $v = 0$, he has a dominant strategy of bidding $b = 0$. As the editor's prior on his expected valuation for a given paper in K must be positive (otherwise he would be a useless editor), a marginal increase in $|L|$—while assuming that the quality standards of the editor, expressed by μ, are constant in $|L|$—increases the probability of finding a paper on the auction market for which $v > 0$. For each such paper, as we will see below, his optimal bidding strategy is $b^* > 0$. Combine this with our assumption that the sets of known papers of editors j and k (K_j and $K_{k\neq j}$) are random draws from ∞. (Thus prob$\{K_j \equiv K_{k\neq j}\} = 0$.) We conclude that an increase in $|L|$ increases the probability that editor j places the highest bid for a paper and thereby increases $|M|$.

$$\frac{dQ}{d\gamma} < 0; \qquad \frac{d^2Q}{d\gamma^2} = 0 \tag{8}$$

$$\frac{dQ}{d|L|} = \frac{dQ}{d\gamma}\frac{d\gamma}{d|M|}\frac{d|M|}{d|L|} > 0; \qquad \frac{d^2Q}{d|L|^2} = 0. \tag{9}$$

Equation (5) characterizes the production function of journal quality. Equations (6), (7) and (9) capture the marginal effects of the efforts of authors, referees and editors on the production of journal quality. Equation (8) is necessary to understand (9).

We make the crucial assumption—following Judge et al. (2007)—that an article's citation revenues increase monotonically in the quality of the journal in which it appears. Formally, let i be one of G papers that cites article ij, let p_i be the price of i in a future auction, and let n_i be the number of articles cited in i. Then, abstracting from time discounting, article ij generates future revenues of:

$$\pi_{ij} = \sum_{i=1}^{G} \frac{p_i}{n_i}. \tag{10}$$

As revenues will be made in the uncertain future, we denote the *expected* revenues of article ij by $\hat{\pi} \equiv \hat{\pi}_{ij}(\cdot)$. By the above argumentation and (10), we have:

$$\frac{d\hat{\pi}}{dQ} = \frac{d\hat{\pi}}{dG}\frac{dG}{dQ} > 0. \tag{11}$$

We assume that $\hat{\pi}$ is non-convex in Q_j, i.e.,[38]

$$\frac{d^2\hat{\pi}}{dQ^2} \leq 0. \tag{12}$$

Summarizing Equations (6), (7), (9) and (11), we get:

Lemma 1 (Expected revenues of an accepted paper) *The expected revenue of an article* ($\hat{\pi}$) *is increasing in the quality of the paper an author submits to the auction* (q), *the effort of a referee to improve the paper* (e), *and the number of papers an editor chooses to learn about* ($|L|$).

A.4 Analysis of the AMJA game

We ignore the possibility of zero strategies and look for a subgame perfect equilibrium that provides positive outcomes.[39] Since there is no optimization in t_4, we start with the referee's optimization problem in t_3 where the referee faces a moral hazard problem concerning acceptance or rejection of the paper he is to review: Since he will only get a payoff if the paper

[38] We assume non-convexity to reflect the fact that journals do not have increasing returns to scale. This is evident in the emergence of more, not bigger, journals in response to the multiplication of fields and demand for publication space. The most recent manifestation is the AER's spawning of four field journals.

[39] One obvious subgame perfect equilibrium of the AMJA game is a strategy combination in which no party exerts any effort, i.e., a *zero equilibrium* where authors invest $q = m = 0$; editors learn about $|L| = 0$ papers and bid $b = 0$ for each paper in an empty set L; referees pick $e = \underline{e}$ but suffer no refereeing disutility because editors send them no papers. No papers are published, and all four parties enjoy induced utility of zero. Nobody has an incentive to deviate as it is only feasible to publish papers cooperatively.

is published (and cited), he is unlikely to recommend rejection.[40] If so, the editor making acceptance decisions in t_4 could use his own ranking of papers within $|M|$ that he got from spending $s'(\cdot)$ in t_1 and could compare the arguments the referee provides with the arguments of another referee in favor of another paper. We conclude that the recommendation of the referee in a one-shot game does not contain useful information for the editor. This does not imply that the referee is useless: He improves the quality of the paper.

Recall that α is the journal's share of future revenue $\hat{\pi}$ for an article published with the expected probability $\hat{\gamma}$, of which the editor gives the share β to the referee. This share extends the objective function of the referee in (4). Therefore, the referee chooses effort e^* to solve the optimization problem:

$$\max_e \hat{\gamma}\alpha\beta\hat{\pi}(e,\cdot) - c_R(e) + u_R(e), \quad \text{subject to } e \geq \underline{e}. \tag{13}$$

We know that referees work (choose positive effort) without explicit remuneration in the CPS. Consequently we must have $u_R(\underline{e}) \geq c_R(\underline{e})$.[41] As the AMJA only adds utility to existing CPS utility—from the same work, we have:

$$\hat{\gamma}\alpha\beta\hat{\pi}(\underline{e},\cdot) + u_R(\underline{e}) > c_R(\underline{e}). \tag{14}$$

We know from Lemma 1 that $\hat{\pi}$ is increasing in e. From (7) and (12), we know the LHS of (14) is concave in e; the RHS, by assumption, is convex. This yields:

Lemma 2 (Effort of the referee) *The optimization problem of the referee*, (13), *has a unique and well defined solution*, $e^* > \underline{e}$.

In period t_2 the editor bids for papers. The value of a paper comes from two properties: a *private value* for editors of certain journals and a *common value* for all editors. Without knowing the mix of private and common values, a bidder does not have enough information to estimate the common value component. Thus, we treat the value of a paper as a random variable whose realizations are i.i.d. Editor j's realization of the random variable is his private information. For simplicity, we specify that editors bid in a sealed-bid second-price auction.[42]

Given that editors may bid for several papers at once and that they face A$ budget constraints, our setting is a private-value, sealed-bid, second-price auction with budget constraints and multiple objects. Che and Gale (1998) have analyzed such a setting for a single object. They find that it is optimal for a bidder to bid the lower of his valuation for the object and his budget. In other words, if the budget constraint is not binding, a bidder bids his

[40] In a repeated version of the game such a proposed pooling equilibrium, where all referees recommend acceptance, is not necessarily stable; referees could build a reputation for honesty and seriousness by rejecting a higher share of papers without effort; see Mailath and Samuelson (2006) for modeling possibilities that we ignore here.

[41] This is a corollary to maximizing (13) when $\hat{\pi} = 0$.

[42] A sealed-bid auction does not rule out the existence of common values: all editors want good papers. Milgrom (1981) has shown that sealed-bid auctions prevent bidders from learning common values through others' bids, resulting in lower bids (to avoid winner's curse) and sub-maximal revenue. Since this characteristic affects all papers equally, and *relative* incomes do not change, we can ignore it. (Recall that our goal is to allocate papers and value articles—not maximize revenues.)

private value v. If the budget constraint is binding, he bids his entire budget.[43] This implies that, if the editor runs out of A$, he simply has to stop bidding for further papers. With respect to multiple objects (papers), we make use of each editor's uncertain knowledge of other editors' budgets.[44] Because no editor knows the number or financial strength of other bidding editors, he has no reason to deviate from the single object equilibrium strategy. Finally, sealed bids also prevent shill bidding and sniping.[45]

An editor's private value v depends on the expected revenues of an article ($\hat{\pi}$), the editor's share of those revenues ($\alpha(1-\beta)$), the probability that a purchased paper will be published (γ), and the cost of finding a referee ($r'(\cdot)$). As $r(|M|)$ is convex, the editor estimates the number of papers he will win as a function of the number of positive bids, $\mu|L|$.

Let $|\hat{M}|$ denote the *expected* number of papers the editor wins using his equilibrium strategy. Since auctions for all papers run simultaneously within one period, the editor in equilibrium will attribute the average cost of refereeing ($\frac{r(|\hat{M}|)}{|\hat{M}|}$) to each paper. We assume that the editor can bid his budget w this period. We also assume that he cannot go bankrupt, i.e., bid more than w for all papers. The editor decides one bid at a time and compares his valuation for that paper v with w, his budget remaining after earlier bids have been subtracted. We establish:

Lemma 3 (Editor bidding) *The optimal bid of editor j on each paper in L is*

(i) $b^* = 0$ *if* $v \leq 0$ *and*
(ii) $b^* = v = \gamma\alpha(1-\beta)\hat{\pi} - \frac{r(|\hat{M}|)}{|\hat{M}|}$ *if* $w > v > 0$ *and*
(iii) $b^* = w$ *if* $w \leq v$.

Before the editor bids in period t_1, he decides to give a preliminary review to $|L|$ papers. He learns his valuation (v) for all $|L|$ at a total cost of $s(|L|)$. His decision on $|L|$ affects the expected number of purchased papers ($|\hat{M}|$) and hence the cost of choosing suitable referees, $r(|\hat{M}|)$.[46] Thus, we rewrite (3) to get the editor's maximization problem:

$$\max_{|L|} \sum_{|X|} \big[\alpha(1-\beta)\hat{\pi}(|L|)\big] - \sum_{|\hat{M}|} p + u_j(Q(|L|)) - \Big[s(|L|) + r(|\hat{M}|(|L|)) + f(|X|)\Big], \tag{15}$$

where $\alpha(1-\beta)\hat{\pi}$ is the editor's share of expected total revenues of one of $|X|$ papers published as articles and $\sum_{|\hat{M}|} p = |\hat{M}|\hat{b}$ denotes the expected price the editor has to pay at auctions for the right to publish $|\hat{M}|$ papers. Note that $f(|X|)$ is independent of $|L|$. The

[43] Benoît and Krishna (2001) show that this result changes if objects have common values and information is complete. Che and Gale (1998) also show that binding budget constraints do indeed affect the revenue equivalence between first-price and second-price auctions. As mentioned in footnote 42, this is not of our concern here.

[44] See Sect. 3.3 for the idea that authors and referees may reassign their A$ to editors after some time. If this happens in anonymity, nobody can guess a certain editor's budget precisely.

[45] *Shill bidding* occurs when someone bids for the author to drive prices up. *Sniping* occurs when someone bids just before the auction ends—and before others have a chance to react—and wins (Roth and Ockenfels 2002).

[46] See footnote 37 for more on the relation between $|L|$ and $|M|$.

first order condition of (15) is:

$$|X|\alpha(1-\beta)\frac{d\hat{\pi}}{d|L|}+\frac{du_j}{dQ}\frac{dQ}{d|L|}=\frac{d|\hat{M}|}{d|L|}\hat{b}+\frac{ds(|L|)}{d|L|}+\frac{dr(|\hat{M}|)}{d|L|}. \tag{16}$$

Since (9), (11) and (12) imply non-convex growth of $\hat{\pi}$ and linear growth of u_j and $|\hat{M}|$ in $|L|$, and $s(|L|)$ and $r(|\hat{M}|)$ are convex, we can state:

Lemma 4 (Editor's optimal set of pulled papers) *The optimization problem of the editor*, (15), *has a unique and well defined solution*, $|L|^* > 0$.

In period t_0 authors decide their effort in marketing papers to editors. Let $\kappa_i = \frac{m_i}{|K'_j|+m_i} \equiv \kappa$, the probability that paper i is among the papers known to editor j, where $|K'_j|$ is the number of papers known to editor j before author i's marketing decision. It follows that $\kappa(m=0)=0$, and κ is concave in m. Given paper $i \in K$, the probability that it is also an element of L is $\frac{|L|}{|K|}$, and the probability that j makes a positive bid for a paper in L is μ. Finally, only γ of the papers purchased by editor j will be published and have a positive expected revenue.

Let us define the *expected publication probability* of paper i (i.e., i's aggregate probability over all journals j of receiving a bid $b>0$, multiplied by the expected probability of publication in journal k ($\hat{\gamma}_k$) that placed the highest bid for i in t_0) as:[47]

$$\rho_i=\sum_j\left(\kappa(m,|K'_j|)\cdot\frac{|L_j|}{|K_j|}\cdot\mu_j\right)\hat{\gamma}_k\equiv\rho. \tag{17}$$

Author i considers all these factors in solving the maximization problem:

$$\max_{m,q}\quad \rho[1-\alpha]\hat{\pi}(q,\cdot)+u_i(q,T)-a(m,q)-\phi, \tag{18}$$

which has first order conditions of:

$$\sum_j\left(\frac{|K'_j|}{(|K'_j|+m)^2}\cdot\frac{|L_j|}{|K_j|}\cdot\mu_j\right)\hat{\gamma}_k[1-\alpha]\hat{\pi}=\frac{da(m,\cdot)}{dm} \tag{19}$$

$$\rho[1-\alpha]\frac{d\hat{\pi}}{dQ}\frac{dQ}{dq}+\frac{du_i(q,\cdot)}{dq}=\frac{da(q,\cdot)}{dq}. \tag{20}$$

$\hat{\pi}$ is independent of m; hence the LHS of Equation (19) is decreasing in m_i, while its RHS is increasing by the convexity assumption. Due to (6) and (12), the LHS of (20) is not increasing in q, while its RHS is increasing by assumption. Thus we establish:

Lemma 5 (Author's optimal efforts to produce quality and marketing) *The optimization problem of the author*, (18), *has one unique and well defined solution*, $q^* > 0$ *and* $m^* > 0$.

[47] One could claim that μ_j depends positively on q_i or negatively on Q_j of the last round. Since we already included effects of higher paper quality in $\hat{\pi}$, we assume μ_j is a fixed parameter.

Notice that the LHS of (19) depends on $\hat{\pi}$, which depends on q. Increased paper quality q has a positive effect on optimal marketing effort m^*. Similarly, according to the LHS of (20), the author's marginal expected revenue from increasing quality q increases in marketing effort m (because $\frac{d\rho}{dm} > 0$), i.e., optimal quality q^* grows in m. Put another way, quality and marketing are complements in the AMJA author's objective function—something that is not necessarily true in the CPS. We summarize our results as:

Proposition 1 (Equilibrium of the AMJA publishing system) *Consider Lemmas 2 through 5. The unique, non-zero, subgame perfect equilibrium of the AMJA game is characterized by the strategies e^*, b^*, $|L|^*$, q^* and m^*.*

A.5 Comparing the CPS and AMJA

A.5.1 The equilibrium of the CPS

First, we characterize the equilibrium of the current publishing system (CPS). Consider the induced utility functions from Sect. A.1: Equation (4) denotes the objective function of a CPS referee. If we assume $u_R(e)$ is concave and $c_R(e)$ is convex in e, the equilibrium strategy of a referee in a functioning CPS (i.e., $u_R(\underline{e}) \geq c_R(\underline{e})$) is to choose effort of:[48]

$$\tilde{e} \geq \underline{e}. \tag{21}$$

A CPS editor's objective function is (3). He chooses a set of papers (W) from the exogenous set of papers pushed at him (N) and gives them preliminary reviews—at a cost $s(|W|)$—within period T. Naturally, we assume the effects of $|W|$ on $|H|$ (the number of papers being sent to referees—and hence on γ and Q—to be the same as those effects of $|L|$ on $|M|$; see (9). If we assume u_j is linear in $|W|$ and $s(\cdot) + r(\cdot)$ is convex in $|W|$, a unique solution to his maximization is:

$$|\tilde{W}| > 0. \tag{22}$$

In the CPS, an author's marketing effort does not improve the quality of his paper, the only measure relevant when rational editors consider papers pushed at them. This is why u_i is independent of m in a CPS author's objective function, (2). Consequently, equilibrium marketing effort is:[49]

$$\tilde{m} = 0. \tag{23}$$

In contrast, q has a positive, non-convex impact on Q, which the editor values positively; see (6). $u_i(q, T)$ is therefore non-convex in q. Since the costs of quality $(a(q))$ are convex in q, the unique equilibrium strategy is:

$$\tilde{q} > 0. \tag{24}$$

Since there is no auction in the CPS, there is no bidding strategy. Our benchmark case for the subsequent comparison is thus:

[48] We will denote equilibrium CPS values with a tilde, e.g., $\tilde{e}$.

[49] Alternatively, one could claim that (as in reality) CPS authors also spend effort on marketing papers, i.e., $\tilde{m} > 0$. This marketing would increase the normalized marketing level and thus m^*; since the effect influences both systems equally, it is irrelevant.

Proposition 2 (Equilibrium of the current publishing system) *Consider* (21) *through* (24). *A unique non-zero, subgame-perfect equilibrium in the CPS is characterized by the strategies* $\tilde{e}$, $|\tilde{W}|$, $\tilde{m}$ *and* $\tilde{q}$.

A.5.2 Comparing equilibria

Compare the referee's objective function in the CPS, (4), to his objective function in the AMJA, (13). The only difference is that the referee gets additional utility in the AMJA, i.e., $\hat{\gamma}\alpha\beta\hat{\pi}(e,\cdot)$. Since $\frac{d\hat{\gamma}\alpha\beta\hat{\pi}(e,\cdot)}{de} > 0$, the referee's equilibrium strategy in the AMJA is:

$$e^* > \tilde{e}. \tag{25}$$

The comparison for editors is more complicated. To compare $|\tilde{W}|$ and $|L|^*$, rewrite the objective function of the AMJA editor in period t_1, (15), as:

$$\sum_{|X|}\big[\alpha(1-\beta)\hat{\pi}(|L|)\big] - |M|\hat{b} + u_j(Q(|L|)) - \Big[s(|L|) + r(|\hat{M}|(|L_j|)) + f(|X|)\Big]. \tag{26}$$

Next, use $|M| = \frac{|X|}{\gamma}$ and replace $\hat{b}$ (the maximum price that editor j could have to pay for each purchased paper) with his valuation $v = \gamma\alpha(1-\beta)\hat{\pi} - \frac{r(|\hat{M}|)}{|\hat{M}|}$; see Lemma 3.[50] Rewriting (26), we get:

$$\frac{|X|}{\gamma}\frac{r(|\hat{M}|)}{|\hat{M}|} + u_j(Q(|L|)) - (s(|L|) + r(|\hat{M}(|L|)|) + f(X)). \tag{27}$$

Note that the CPS editor's objective function, (3), lacks $\frac{|X|}{\gamma}\frac{r(|\hat{M}|)}{|\hat{M}|}$. When calculating the FOC of (27), note that $\frac{d\gamma}{d|L|} < 0$ (hence $\frac{|X|}{\gamma}$ increases in $|L|$) and that $\frac{r(|\hat{M}|)}{|\hat{M}|}$ also increases in $|L|$ (from the convexity of $r(\cdot)$). Consequently, an editor gains more utility at the margin from increasing $|L|$ in AMJA than from increasing $|W|$ in CPS. This leads to:

$$|L|^* > |\tilde{W}|. \tag{28}$$

For authors, compare the FOC of (2) within the CPS to (20) within the AMJA. The only difference is that increasing quality gives the author in the AMJA an additional marginal benefit of:

$$\rho[1-\alpha]\frac{d\hat{\pi}}{dQ}\frac{dQ}{dq}, \tag{29}$$

which is positive for $m^* > 0$. This provides us with the insight that:

$$q^* > \tilde{q}. \tag{30}$$

Finally, we state as a corollary to Lemma 5 and (23) that:

$$m^* > \tilde{m}. \tag{31}$$

These insights allow us to state two further results:

[50] For every price $p < v$ the editor's incentive to increase $|L|$ is even more pronounced.

1. According to (6) to (9), the average quality of articles in a journal (Q) increases in q, e, and $|L|$. Consequently, by considering the comparative results of (25), (28) and (30), we have:[51]

$$Q^* > \tilde{Q}. \tag{32}$$

2. With $e^* > \tilde{e}$ and, by assumption, $\frac{dT}{de} < 0$, we have:

$$T^* < \tilde{T}. \tag{33}$$

These results complete our equilibrium analysis.

A.5.3 Pareto-optimality

What claims can we make from our results about the well being of authors, editors, referees and readers? Ignoring the transition from one system to another (see Sect. 3.7), we compare the expected, induced utility of each party in both systems.

Readers are better off in the AMJA. Reader utility rises with journal quality (Q) and falls with time to publication (T). Since both equilibrium values improve in the AMJA system (according to (32) and (33)), we get:

$$\nu_C^* > \tilde{\nu}_C. \tag{34}$$

Why do referees, editors, and authors choose higher values for e, $|L_j|$, q_i and m_i in the AMJA system? If players increase their inputs *voluntarily*—based on a comparison of expected marginal utility and marginal costs of such an increase, it must be because they expect higher induced utility in the AMJA system.

This conclusion is simple for editors and referees because they only gain—and do not lose—utility in the AMJA system, i.e.,

$$\nu_j^* > \tilde{\nu}_j \tag{35}$$

$$\nu_R^* > \tilde{\nu}_R. \tag{36}$$

For authors, the AMJA is better *only if* additional induced utility exceeds additional disutility, i.e.,

$$\rho(m^*)[1-\alpha]\hat{\pi}(q^*) + (u_i(T^*) - u_i(\tilde{T})) > \phi. \tag{37}$$

Thus, if the costs of posting a paper to the auction server (ϕ) are too high, authors will not contribute. If authors differ (e.g., through heterogeneous abilities), they have different cost functions ($a(q,m)$) for increasing paper quality and marketing, which results in different levels of q^* and m^*. To maximize participation, ϕ must be low enough to attract higher cost authors.[52]

[51] For clarity reasons we denote the AMJA (CPS) equilibrium value of Q by Q^* ($\tilde{Q}$) and will do the same for other variables below. We are aware that those are not strategic variables in the strict sense.

[52] This insight opens an entire discussion on the potential goals (and welfare) of the academic community as a whole: Is it better to encourage every author to post papers to the auction server by charging low ϕ—thus allowing unsuccessful papers to subsidize more successful papers—or should a certain threshold for quality of papers (and marketing efforts) be set indirectly by charging high ϕ?

Finally, since author i spends $a(m^* > 0) > 0$ voluntarily, the author trades loss for gain while (37) holds.[53] We conclude:

$$\nu_i^* > \tilde{\nu}_i, \tag{38}$$

which allows us to state our main result:

Proposition 3 (Pareto-optimality) *Consider* (34) *through* (38). *As long as the submission fee to the auction server* (ϕ) *is sufficiently low, the equilibrium of the AMJA is strictly Pareto-superior to the equilibrium of the CPS.*

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[53] Notice that there is a *positive* externality of m. Suppose an author writes a paper with high q. Increasing m increases the probability that it is known to editors, who are more likely to give it a preliminary review and bid for it. If this means journal quality (Q) rises to benefit readers and editors directly and $\hat{\pi}$ rises—see (11)—to benefit editors and referees indirectly, then effort spent on marketing a good paper benefits society. The contrary is also true: more marketing for a low quality paper results in either no bids (wasted marketing effort) or displacement of a better, but less marketed, competitor, which harms society and efficiency.

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