A Model of the Editorial Process in Scientific Journals

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Abstract

We develop a model of the editorial process in scientific journals and institutions awarding research grants. A journal editor wishes to maximize his journal’s expected payoff from publishing high quality papers, net of costs due to (mistakenly) publishing low quality papers. The editor has a prior probability assessment about the quality of submitted papers, but may benefit from additional costly evaluations performed by (one or two) referees. Referees receive noisy signals about a paper’s quality. While some referees (“generalists”) are neutral regarding the paper, others (“experts”), with more precise signals than generalists, also have a bias (positive or negative) regarding the paper. The editor’s job in our basic model is therefore to decide whether or not to desk-reject (or accept) a paper based on his prior evaluation of the paper’s quality, whether to send it out for refereeing, and if so, to choose the kind and number of referees, and finally to optimally accept or reject the paper using all available information. In our extended strategic reporting model, we allow the editor to generate an additional signal regarding a paper’s quality and each referee to choose how biased a report to send to the editor, knowing that the editor has the ability to impose a penalty on referees who he believes knowingly sent biased reports. Our model generates a number of testable predictions and policy implications regarding how to improve the editorial process in scientific journals and the evaluation of research proposals.

JEL classification: D82; D83; G31.

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1 Introduction

Peer reviewing has been the mainstay of academic research, both for publication in academic journals and for awarding research grants. However, peer review has also become controversial.\(^1\) On the one hand, peer review is crucial in preventing the publication of questionable or even fraudulent research.\(^2\) On the other hand, there is significant anecdotal evidence that paradigm-shifting innovations are met with considerable hostility by the scientific community, which may translate into poor reviews and therefore difficulty in publishing. While some of the most well known cases of these occurred a long time ago (e.g., the negative reception given to the works of Nicolaus Copernicus and Galileo Galilei regarding heliocentrism), the problem of the difficulty in publishing (or getting research support for) more innovative or controversial findings continues to the present day. Many critics of peer review have argued that papers with findings that challenge their existing beliefs are treated more harshly by journal reviewers. For example, in a survey of applications for National Cancer Institute funding in 1980, when asked whether they were reluctant to support unorthodox or high-risk research, 60.8% of applicants agreed (Chubin and Hackett, 1990). Similarly, in a survey of the editors of sixteen leading American Psychological Association journals, Armstrong and Hubbard (1991) report that these editors were disappointed that few papers with controversial findings were submitted, and when such papers were submitted, few were favorably reviewed by the referees. Finally, Gans and Shepherd (1994) examine the reception given to new ideas in economics, discussing the experience of some leading economists with various journals, and documenting some papers, later regarded as classics, that were initially rejected from some top journals (Table 1 of their paper).\(^3\) There are also many similar anecdotes from medical research, where researchers deviating from the prevailing orthodoxy either could not get funding, or if funded, had greater difficulty in publishing their research.\(^4\)

\(^1\)See, e.g., Weller (2001) for a discussion of the strengths and weaknesses of editorial peer review.

\(^2\)One prominent example of a piece of fraudulent research published in a top scientific journal is the publication in Science of a South Korean cloning pioneer that later unraveled and led to criminal indictment and retraction of the article by Science. More recently, NASA research by Wolfe-Simon et al. (2010) appearing to show bacteria could substitute arsenic for phosphorus in their DNA has been published online in Science, but it has been severely discredited as wrong by other scientists after its publication.

\(^3\)Gans and Shepard (1994) quote the Nobel Prize winner Paul Samuelson: “Yes, journals have rejected papers of mine, some of them later regarded as ‘classics’. Their survey of leading economists found that many that have become classics were rejected by at least one journal and often by more than one.

\(^4\)One such anecdote is regarding the causes of Alzheimer’s disease. The prevailing orthodoxy in the medical research community over a long period of time has been that beta amyloid plaques and neurological tangles in the brain cause dementia (memory loss and associated symptoms) in this disease. However, in a recent article (Castellani et al., 2009)
In summary, while peer review provides many useful functions such as correcting errors in papers and providing a “fair” way to allocate journal space and research funds, it also seems to suppress innovation in scientific research. It is therefore important to examine whether peer review, as it stands now in most journals and institutions awarding research grants, is the optimal procedure, or whether it can be improved. Surprisingly, while there has been a significant amount of empirical evidence regarding the effectiveness of peer review, both in journals and in institutions such as National Science Foundation (see, e.g., Cherkashin, Demidova, Inmai, and Krishna (2009) and Ellison (2002a, 2002b, and 2007) for empirical evidence on peer review in journals, and, e.g., Abrams (1991) for evidence on the peer review of research grant proposals), there is little theoretical analysis of the editorial process in scientific journals and how it can be improved. The objective of this paper is to fill this gap in the literature by developing a theoretical model of the editorial process.

We make use of our model to address several interesting questions regarding the editorial process in scientific journals or by institutions awarding research grants. The first question is regarding the selection of referees. In particular, how close should the referee’s expertise be to the subject matter of the paper, given that referees with the greatest expertise in an area may also be the ones that may be the most highly opinionated, and thus likely to have strong biases, either favorable or unfavorable, regarding the paper? A related question is regarding the number of referees: should the editor use one referee or multiple referees to evaluate a paper? How should an editor’s prior opinion of a paper (which may be influenced in part by the reputation of the authors) affect his choice of the referee and the number of the referees? How much influence should the authors of manuscripts have in the editor’s choice of referees (if any)? How does the expertise of a journal’s editor affect the quality

Dr. Rudy Castellani, Professor of Pathology at the University of Maryland, argues that this hypothesis is wrong, and that abnormal accumulations of beta amyloid (the protein in plaques) and tau (the protein in tangles) are not harmful, and are simply end-stage signs of the disease. To quote Dr. Castellani: “Unfortunately, there is a lot of money and associated influence, as well as prestigious names and titles with a personal stake in the ultimate success of treatment efforts modeled after their preferred construct. Alzheimer’s research involves selling ideas as much as (and more in my view) objective pursuit of knowledge. In this respect, the peer review process is a bit of a farce, as it encourages fealty to existing ideas and hampers innovation, in spite of unending lip service paid to the latter.”

There is also some evidence in the specific context of the finance literature: see Welch (2011) for evidence on the informativeness of referees based on the Society for Financial Studies Cavalcade (2011) and Spiegel (2011) for a discussion of his experience of the editorial process as the Executive Editor of the Review of Financial Studies. See also Harvey (2013), who discusses his experience as the editor of the Journal of Finance, and McAfee (2010) who discusses his experience and insights as a co-editor of the American Economic Review.

An exception is Ellison (2002a), who develops a model attempting to explain why quality standards in journals have evolved over time with increases in revision time, longer introductions and literature reviews and so on. We will discuss how our paper relates to Ellison (2002a) later in Section 2.
of the referee reports provided to him? How does the nature of its dispute resolution procedure affect the quality of the editorial decisions made by a journal? In answering the above questions, an important consideration is a journal’s objective: how much importance does the journal place on avoiding rejecting high quality papers (i.e., minimizing type I errors) versus avoiding the acceptance of low quality papers (i.e., minimizing type II errors)?

We address the above and other related questions using a model of a journal’s editorial process. In our model, a journal editor has the objective of maximizing his journal’s expected payoff from publishing high quality papers, net of its costs arising from (mistakenly) publishing low quality papers. While the editor has a prior probability assessment regarding the quality of papers that are submitted to his journal, in many cases he can benefit from additional evaluations of these papers performed by (one or more) referees. Potential referees receive noisy signals about a paper’s quality. While some referees ("generalists") are neutral regarding the paper, other referees ("experts"), who have a more precise signal regarding paper quality than generalists, may also have a bias (positive or negative) regarding the paper. We assume that considerations of cost limit the number of referees that the editor can choose to call upon to a small number (specifically, two). In our basic model, expert referees are endowed with their bias, and cannot change this bias strategically. Further, the editor does not have the ability to generate additional signals of his own (beyond his prior evaluation) regarding paper quality or impose any penalties on referees he believes made a biased report to him. The editor’s job in the basic model is therefore to decide whether or not to desk-reject (or accept) a paper based on his prior evaluation of the paper’s quality, whether to send it out for refereeing (and if so, to choose the kind and number of referees to send the paper to), and upon receiving one or more referee reports, to optimally make use of the information in these reports to accept or reject the paper.

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7 One aspect of the editorial process in scientific journals that we do not study is its ability to improve the paper over various refereeing rounds. We choose not to study this, given that our focus in this paper is on how an editorial process can achieve an optimal balance between type I and type II errors: i.e., ensuring that truly good papers are accepted for publication and bad papers get rejected. However, one way to incorporate the possibility of improving a paper through the refereeing process into our model is to think of “acceptance” in our model as really being a “revise and resubmit” leading to further improvements in the paper over subsequent rounds.

8 An interesting question that arises here is why desk acceptances are not commonly observed in practice. One possible reason may lie in the ability of the refereeing process to improve papers over multiple rounds (not modeled here). Thus, editors may choose to send even papers about which they have a very high prior to a referee in order to improve their quality. Alternatively, editors may choose to send even papers regarding which they have a high prior to a referee in order to validate their acceptance of the paper from an outside agent, thus demonstrating that the acceptance was not a result of favoritism; the latter motivation is also not modeled in this paper.
In our extended (“strategic reporting”) model, we build on our basic model but allow the editor to generate his own additional signal regarding a paper’s quality, though the precision of this signal depends on how much of his limited resources (e.g., time or effort) the editor devotes toward evaluating a paper. Further, we also allow each referee to strategically choose how biased a report to send to the editor, knowing that, if the editor suspects a referee of sending a biased report, he has the ability to impose a penalty on him. The additional signal generated by the editor therefore not only gives him more information to evaluate the paper, but also affects the quality (bias) of the referee’s report. In the equilibrium of this strategic reporting model, the editor not only chooses the nature of the referee, but also how much resources to devote to evaluating the paper, and finally makes the accept or reject decision on the paper based on his own signals and the referee’s report to him.

Our analysis generates a number of empirical and policy implications regarding the editorial process in scientific journals, and how it can be improved. The first set of implications from our basic model is regarding a journal’s choice of the nature of referees to evaluate a paper. Our analysis demonstrates that choosing a referee with the greatest expertise in the scientific area closest to that of the paper is not always optimal from the point of view of the journal. This is because the referee who is most knowledgeable in the scientific area related to the paper may also be the one who is most biased (either positively or negatively) toward innovative or controversial ideas in that area. Thus, our analysis suggests that the choice of referee should be made by trading off the superior knowledge of an expert referee with the greater impartiality of a generalist. Further, in situations where it is indeed optimal to use an expert referee due to his superiority in area-specific knowledge over the generalist, the editor should account for the potential bias of this expert referee (to the extent possible) in making editorial decisions.

The second set of implications from our basic model deals with the journal’s choice between one versus two referees. Our analysis suggests that, if the editor can aggregate the information contained in referee reports efficiently (using Bayes’ rule), then this choice depends on the trade-off between the cost involved in hiring an additional referee versus the benefit of doing so, which arises from the additional information provided by this referee. Somewhat surprisingly, this is the case not only for generalist referees, but also for the choice between one versus two expert (but biased) referees: the editor is always able to extract some useful information even from an additional biased report from
an expert referee, so that, if the additional cost involved is very small, two referees are always better than one. However, in practice, many journals may adopt *ad hoc* rules for aggregating the information from multiple referees (rather than Bayes’ rule), such as requiring both referees to make favorable recommendations before a paper can be accepted by the journal. Our analysis shows that, under such *ad hoc* rules, it is no longer the case that two referees are always better than one, even when the marginal cost of using an additional referee is zero: we show that, in such cases, the incremental bias introduced by having a second referee evaluate the paper may overcome the benefit of the incremental information obtained by the editor by using an additional referee.

The third set of implications from our basic model deals with the relationship between the journal editor’s prior belief about a paper’s quality and the nature of referees used to evaluate it. We discuss here the case where the expert referee’s bias is moderate. First consider the one referee case. Our analysis suggests that, consistent with practice, an editor who has a very low prior opinion of a paper will desk-reject a paper; an editor with a very high prior opinion of a paper will desk-accept it. Further, if the editor has a low prior opinion of a paper (but this opinion is above the desk-rejection region), he will optimally send it to a negatively biased expert referee. On the other hand, if the editor has a high prior opinion of the paper (but below the desk-acceptance region) he will optimally send it to a positively-biased expert referee. Finally, if the editor’s prior opinion is in-between the above two regions, he will optimally send it to a generalist.

The implications regarding the two referee case is somewhat similar to the one referee case discussed above. Leaving aside the very low prior opinion (desk-reject) and very high prior opinion (desk accept) regions, in the two referee case the editor will choose two positively biased expert referees if his prior is immediately below the desk accept region; he will choose two negatively biased expert referees if his prior is immediately above the desk-reject region. For values of his prior in the two regions adjacent to the above mentioned regions (with referees of similar bias), the editor will choose expert referees with opposite biases: in other words, if his prior is above the region where he opts for two negatively biased expert referees or below the region where he opts for two positively biased expert referees, he will optimally choose two expert referees with biases opposite to each other to evaluate the paper. Finally, if his prior is in-between the above two regions where he opts for two expert referees of opposite biases, he will choose two generalists to evaluate the paper.
Our strategic reporting model has several implications for the relationship between the characteristics of a journal's editor and the information to bias ratio of the recommendations provided to it by referees. First, our model suggests that, if the editor is more able, so that his own signal regarding a paper is more precise for a given amount of resources he commits to it, then the referee is likely to strategically lower his bias, thus increasing the information to bias ratio of his reports to the editor. Second, if the editor is able to impose larger penalties on referees who he assesses have turned in biased reports, then the information to bias ratio of the referee’s reports to the editor will be greater. Third, our analysis suggests that, in many cases, it is optimal for the editor to override a referee’s recommendation based on his own signal: i.e., accept a paper in the face of a negative recommendation from a referee or reject a paper in the face of a positive recommendation.

Our strategic reporting model also has implications for a journal’s dispute resolution procedure (if one exists).\(^9\) First, the presence of a dispute resolution procedure not only provides an additional signal to the editor (when it is invoked by a paper’s author), but the possibility of the author invoking this procedure will also increase the informativeness to bias ratio of the first referee’s report (assuming that the editor will impose a penalty on the first referee if the dispute referee disagrees with the first referee). Second, our analysis suggests that the dispute referee should be asked to produce a completely independent signal rather than his signal being influenced by the first referee in some form (for example, by being provided with the first referee’s report), since this will provide the greatest disciplining effect on the first referee, thus increasing the informativeness to bias ratio of his report to the greatest extent.

Even though the most direct application of our analysis is in the evaluation of manuscripts submitted for publication by journals and in the evaluation of research grant proposals by funding agencies, it has significant applications to corporate finance as well. First, much of the funding of basic science by universities, non-profits, or national funding agencies (such as the NSF or NIH) are done based on the assessment of outside referees which falls within the framework of our model. There is empirical evidence to show that, this funding, in turn, affects the formation of new private firms. Second, in certain industries such as pharmaceutical and medical device industries (and in human and animal

\(^9\)Even though we do not formally model a dispute resolution procedure, the additional signal generated by the editor in our strategic reporting model can be viewed as arising from such a procedure.
health sciences industries in general), the widespread adoption of a product is based on clinical trials, which are then evaluated by top journals in their fields and also by regulatory and licensing agencies with the help of outside referees. Finally, our model has implications for any setting where funding is provided or derived based on the advice of (potentially conflicted) outside experts: for example, the provision of seed funding to entrepreneurial firms by universities or non-profit business incubators.

The rest of the paper is organized as follows. Section 2 discusses how our paper is related to the existing literature. Sections 3, 4, 5, and 6 present our basic model: Section 3 presents the model setup; Section 4 presents the analysis of an editor's choice (of one referee) among a positively biased expert referee, a negatively biased expert referee, and a generalist referee; Section 5 analyzes the case where the editor can send the paper to two referees, and processes information contained in referee reports using Bayes' rule; Section 6 analyzes the same situation under an *ad hoc* information processing rule. Section 7 presents our strategic reporting model. Section 8 describes the empirical and policy implications of our analysis, and Section 9 concludes. The proofs of all propositions are in the Appendix.

## 2 Related Literature

Our paper is related to Ellison (2002a), who develops a model attempting to explain why quality standards in journals have evolved over time with increases in revision time, longer introductions and literature reviews and so on. In his *q − r* model, paper quality has two dimensions: *q* measures the main contribution of the paper, and *r* measures other aspects of quality. He uses the model to study how the trade-off between *q* and *r* changes over time as social norms change (and referees use these norms to evaluate papers). Unlike his model, our focus here is on theoretically analyzing how editors can improve the editorial process, increasing the probability of high quality papers being accepted and low quality papers being rejected.

Our paper is also related to the strand of the theoretical economics literature that deals with the design of mechanisms by a decision maker who has to rely on the opinions and advice of interested parties and biased experts. Crawford and Sobel (1982) study strategic information transmission between two parties, one of whom has useful information for the other. Their focus is on conditions under
which “cheap talk” can occur and cause information loss in equilibrium when communication between the uninformed party and the perfectly informed party is direct and costless. Milgrom and Roberts (1986) analyze how competition among interested parties attempting to influence a decision maker by providing verifiable information can elicit truthful information revelation in a setting with an infinite number of competing experts. Gilligan and Krehbiel (1989) study a model in which privately (and perfectly) informed committees report in front of the floor before a decision is taken by majority rule, and they compare “closed rules” in which the floor delegates the decision to a committee to “open rules” in which the committees can only make a report.

Krishna and Morgan (2001) study a model in which two perfectly informed, biased experts simultaneously offer advice to a decision maker whose actions affect the welfare of all, and they claim that when experts are biased in opposite directions, it is always beneficial to consult both. Clearly, in our setting of scientific journal referees, it is not realistic to expect the referees to be perfectly informed about the quality of a paper. Austen-Smith (1990) studies information transmission in debates with imperfectly informed experts. However, he does not focus on the conditions under which the decision maker can achieve maximum information revelation. Dewatripont and Tirole (1999) examine reward schemes to induce information gathering by “advocates” and show that informational benefits are maximized by making each of the advocates responsible for a distinct area and compensating them accordingly. Battaglini (2004) studies policy advice by several experts with noisy private information and biased preferences, and highlights the trade-off between the truthfulness of the information revealed by each expert and the number of signals from different experts that can be aggregated to reduce noise. He shows that communication inefficiency can be reduced to zero as the number of similarly biased experts tends to infinity. Clearly, none of the above papers build a theory that applies specifically to the setting of the editorial process in scientific journals. In particular, it is not realistic to expect that journal referees (experts) receive perfectly informative signals about the intrinsic quality of reviewed papers. It is also not practical that a journal editor (decision maker) can

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10 Austen-Smith (1993) uses the same approach to analyze the case of multiple expert referrals under an open rule decision procedure, and finds that sequential consultation with multiple experts is better than simultaneous consultation. He argues that there is little difference between like and opposing biases of the two experts.

11 Wolinsky (2002) considers a decision setting in which there are more than two biased experts with noisy signals, and is interested in the optimal organization of communication procedures among all parties. Dessein (2002) builds a theory of delegation based on information transmission between a single informed expert and a decision maker.

12 Ottaviani and Sorensen (2006) study reputational issues with multiple experts.
ask a huge number of multiple referees to review a given paper in order to minimize the noise and the biases inherent in the editorial process. Further, journal editors do not possess the ability to impose large penalties on referees to induce perfect truthtelling by them.

3 The Model

The intrinsic quality of a paper can take two values: good, denoted by $G$, or bad, denoted by $B$. The editor has a prior belief about the quality of the paper being submitted as follows:

$$P(G) = g, P(B) = 1 - g.$$  \hspace{1cm} (1)

The editor’s payoff to rejecting a paper is normalized to 0. The editor’s payoff to accepting a good paper is equal to $R > 0$, and his payoff to accepting a bad paper is equal to $-L < 0$, where $R$ and $L$ are positive constants. Thus, based on his priors only, the editor will desk-accept a paper if and only if the following condition holds:

$$gR + (1 - g)(-L) > 0,$$  \hspace{1cm} (2)
which is equivalent to

\[ g > \bar{g} \equiv \frac{L}{L + R}. \] (3)

Note that the threshold value \( \bar{g} \) for the editor’s prior belief is increasing in \( L \) and decreasing in \( R \).\(^\text{13}\) Thus, as the cost of accepting a bad paper (i.e., committing a type II error), \( L \), increases, the editor becomes less likely to accept a paper based on his prior belief only. If the condition in (3) is not satisfied, the editor will *desk-reject* the paper.

However, the editor may be able to make a more informed decision by employing a referee at a fixed cost of \( c \) than just desk-reject or desk-accept the paper based on his prior beliefs. Based on their expertise in their scientific subject fields, referees can acquire more precise signals about the quality of a submitted paper, and thus, improve upon the prior belief of the editor by producing some information about the paper’s quality. We will assume that there are two types of referees the editor can choose from: generalist referees or expert referees. In the next subsections, we will define the characteristics of each type of referee and analyze their actions.

### 3.1 The Generalist Referee

After reading the paper, the generalist referee will generate a binary private signal \( s \) \((s = s_H \text{ or } s = s_L)\) about the quality of the paper with the following properties:

\[ P(s_H \mid G) = p_1, \quad P(s_H \mid B) = 1 - p_1. \] (4)

where \( 0.5 < p_1 < 1 \).

Based on his private signal, the generalist referee will then generate a binary report \( m \) \((m = m_H \text{ or } m = m_L)\) which he will then send to the editor. We assume that the generalist referee always reports his signal to the editor truthfully, i.e., \( P(m = m_H \mid s_H) = 1 \) and \( P(m = m_L \mid s_L) = 1 \). This implies that the conditional probabilities of the generalist referee submitting a positive referee report to the

\(^{13}\)Note that \( \frac{\partial \bar{g}}{\partial L} = \frac{R}{(L + R)^2} > 0 \) and \( \frac{\partial \bar{g}}{\partial R} = -\frac{1}{(L + R)^2} < 0 \).
editor are given by:

\[ P(m_H | G) = p_1, \quad P(m_H | B) = 1 - p_1. \]  

(5)

Therefore, the unconditional probability of the editor receiving a positive referee report from a generalist referee is given by:

\[ P(m_H) = P(G)P(m_H | G) + P(B)P(m_H | B) = gp_1 + (1 - g)(1 - p_1). \]  

(6)

After receiving a report from a generalist referee, the editor revises his belief about the quality of the paper using Bayesian updating. If the editor receives a positive referee report \((m = m_H)\), his posterior belief that the paper is of good quality, denoted by \(\hat{g}_H\), is given by

\[ \hat{g}_H = P(G | m_H) = \frac{gp_1}{gp_1 + (1 - g)(1 - p_1)}. \]  

(7)

Since the referee’s signal is informative, i.e., \(p_1 > 0.5\), it follows that \(\hat{g}_H > g\). Thus, if the editor receives a positive referee report, his posterior assessment of the paper is higher than his prior assessment of the paper.

Similarly, if the generalist referee receives a negative referee report \((m = m_L)\), his posterior belief that the paper is of good quality, denoted by \(\hat{g}_L\) is given by

\[ \hat{g}_L = P(G | m_L) = \frac{g(1 - p_1)}{g(1 - p_1) + (1 - g)p_1}. \]  

(8)

Since the referee’s signal is informative, i.e., \(p_1 > 0.5\), it follows that \(\hat{g}_L < g\). This implies that if the editor receives a negative referee report, his posterior assessment of the paper is lower than his prior assessment of the paper.

The editor’s ex-ante expected payoff from employing a generalist referee can be expressed as follows:

\[ P(m_H) \cdot \max\{0, \hat{g}_H R - (1 - \hat{g}_H)L\} + P(m_L) \cdot \max\{0, \hat{g}_L R - (1 - \hat{g}_L)L\} - c. \]  

(9)

\(^{14}\)The unconditional probability \(P(m_L)\) of the editor receiving a negative referee report from a generalist referee is \((1 - P(m_H))\), which is equal to \((g(1 - p_1) + (1 - g)p_1)\).
Thus, if the editor receives a positive referee report (with the unconditional probability $P(m_H)$ given in (6)), he will compare his payoff from rejecting the paper (a certain payoff of 0) to his expected payoff from accepting the paper conditional on a positive report, which is equal to $(\hat{g}_HR - (1 - \hat{g}_H)L)$. On the other hand, if the editor receives a negative referee report (with the complementary probability $P(m_L) = (1 - P(m_H))$), he will also compare his payoff from rejecting the paper (a certain payoff of 0) to his expected payoff from accepting the paper conditional on a negative report, which is equal to $(\hat{g}_LR - (1 - \hat{g}_L)L)$. Finally, the editor subtracts the fixed cost $c$ of employing a generalist referee.

The editor will reject the paper after receiving a negative referee report, if and only if his posterior assessment of the paper, $\hat{g}_L$, is less than or equal to the threshold value $\bar{g}$ given in (3) (i.e., $\hat{g}_L \leq \bar{g}$), since $(\hat{g}_LR - (1 - \hat{g}_L)L) \leq 0$ if and only if $\hat{g}_L \leq \bar{g}$. Otherwise, if $\hat{g}_L > \bar{g}$, the editor would accept the paper even after receiving a negative report, in which case case acceptance would dominate employing a generalist referee ex ante. The restriction $\hat{g}_L \leq \bar{g}$, translates into the following restriction on the editor’s prior:

$$g \leq \frac{p_1L}{p_1L + (1 - p_1)L}. \quad (10)$$

In other words, if the editor’s prior probability $g$ for a paper is below the threshold given in (10), then he will reject that paper if he receives a negative report on it from a generalist referee.

Similarly, for an editor to accept a paper for which he receives a positive referee report, his posterior assessment of the paper, $\hat{g}_H$, must be greater than the threshold value $\bar{g}$ (i.e., $\hat{g}_H > \bar{g}$), since $(\hat{g}_HR - (1 - \hat{g}_H)L) > 0$ if and only if $\hat{g}_H > \bar{g}$. Otherwise, if $\hat{g}_H \leq \bar{g}$, the editor would reject the paper even after receiving a positive report, in which case desk rejection would dominate employing a generalist referee ex ante. The restriction $\hat{g}_H > \bar{g}$, translates into the following restriction on the editor’s prior:

$$g > \frac{(1 - p_1)L}{p_1R + (1 - p_1)L}. \quad (11)$$

In other words, if the editor’s prior probability $g$ for a paper is above the threshold value given by (11), then he will accept the paper if he receives a positive report on it from a generalist referee.

In summary, for values of the editor’s prior $g$ falling in the interval characterized by (10) and (11),
the editor would accept a paper with a positive report and reject one with a negative report: i.e., in this interval of his prior, the editor would solicit a referee report, provided that the cost of refereeing is sufficiently small. Substituting these threshold values into (9), the editor’s expected payoff from employing a generalist referee simplifies to:

\[
P(m_H) \cdot [\hat{g}_H R - (1 - \hat{g}_H)L] - c = gp_1 R - (1 - g)(1 - p_1)L - c. 
\]  

(12)

The following proposition characterizes the editor’s optimal refereeing decision when only a generalist referee is available to him.

**Proposition 1 (Editor’s Choice between Desk Acceptance, Desk Rejection, and a Generalist Referee)** Let \(c < (2p_1 - 1) \frac{LR}{L+R}\). Suppose that there only exists the generalist referee. If the editor’s prior probability assessment \(g\) about the quality of the paper is low, so that \(0 < g \leq k_1\), it is optimal for the editor to desk-reject the paper. If the editor’s prior probability assessment \(g\) about the quality of the paper is moderate, so that \(k_1 < g < s_1\), it is optimal for the editor to request a referee report from a generalist referee. If the editor’s prior probability assessment \(g\) about the quality of the paper is very high, so that \(s_1 \leq g < 1\), it is optimal for the editor to desk-accept the paper.

The intuition behind the above proposition is as follows. First, consider the case when the editor’s prior is less than or equal the threshold \(\hat{g}\) (\(g \leq \hat{g}\)). In this case, if the editor does not employ a referee, he will desk-reject the paper, since \(gR - (1 - g)L \leq 0\). His payoff from desk-rejection will be equal to 0. Thus, ex ante, the editor will choose to employ a generalist referee, if and only if his expected payoff from employing a generalist referee is greater than the zero payoff he receives from desk rejection:

\[
gp_1 R + (1 - g)(1 - p_1)L - c > 0. 
\]  

(13)

We can equivalently express this condition as a restriction on the prior belief \(g\) of the editor. Thus, if \(g \leq \hat{g}\), the editor will prefer desk rejection to employing a referee if and only if the following condition holds:

\[
0 < g \leq k_1 \equiv \frac{c + (1 - p_1)L}{p_1 R + (1 - p_1)L}. 
\]  

(14)

Therefore, if \(k_1 < g \leq \hat{g}\), the editor will optimally choose to send the paper to the generalist referee rather than simply desk-reject it based on his prior.
Second, consider the case when $g > \bar{g}$. In this case, if the editor does not employ a referee, he will desk-accept the paper based on his prior belief, since $gR - (1 - g)L > 0$. Thus, ex ante, the employee will choose to send the paper to the generalist referee, if and only if his expected payoff from employing a generalist referee is greater than his expected payoff from desk acceptance:

$$gp_1R - (1 - g)(1 - p_1)L - c > gR - (1 - g)L.$$  \hspace{1cm} (15)

Once again, we can equivalently express this condition as a restriction on the prior belief $g$ of the editor. Thus, if $g > \bar{g}$, the editor will prefer desk acceptance to employing a referee if and only if the following condition holds:

$$s_1 \equiv \frac{p_1L - c}{p_1L + (1 - p_1)R} \leq g < 1.$$  \hspace{1cm} (16)

Therefore, if $\bar{g} < g < s_1$, the editor will optimally choose to send the paper to the generalist referee rather than simply desk-accept it based on his prior.

In summary, if the editor’s prior falls in the interval $(k_1, s_1)$, the editor finds it worthwhile to send the paper to a generalist referee rather than desk-rejecting or desk-accepting it. The restriction on the fixed cost of employing a referee, $c < (2p_1 - 1)\frac{LR}{L+R}$, ensures that the interval $(k_1, s_1)$ is well-defined.

3.2 The Expert Referee with a Negative Bias

We now introduce a second type of referee, which we call the expert referee, into the model. An expert referee is able to obtain a more precise signal about the quality of the paper than the generalist referee, since he is an expert scholar in the subject field of the paper. One can fairly assume that the expert referee is very well published in this field, and that he derives substantial benefits from controlling his intellectual domination over that research subject. Therefore, it may be the case that he is negatively biased against competing papers in his field of expertise. On the other hand, an expert referee may also be positively biased with respect to certain papers since he may expect to get benefits in the future in exchange for being more lenient in his critical review of these papers. In this subsection, for ease of exposition, we will assume that the expert referee is negatively biased only (we discuss the
positively biased referee later).

After reviewing the paper, the expert referee receives a binary private signal \( s \) (\( s = s_H \) or \( s = s_L \)) with the following properties:

\[
P(s_H | G) = p_2, \quad P(s_H | B) = 1 - p_2.
\]

(17)

where \( 0.5 < p_1 < p_2 < 1 \). Thus, the expert referee is able to generate a more precise and informative signal than the generalist referee, since \( p_2 > p_1 \).

We assume that a negatively biased expert referee will adopt the following (biased) reporting strategy after obtaining his signal \( s \):

\[
P(m = m_H | s_H) = 1 - b, \quad P(m = m_L | s_L) = 1.
\]

(18)

Thus, if a negatively biased expert referee receives a positive private signal \( (s = s_H) \) about a paper, he reports it truthfully \( (m = m_H) \) only with probability \( (1 - b) \). In other words, he issues a negative report \( (m = m_L) \) with probability \( b \), whenever he receives a positive signal. On the other hand, if he receives a negative signal \( (s = s_L) \), he reports it truthfully \( (m = m_L) \) with probability \( 1 \). Thus, the quantity \( b \) \((0 < b < 1)\) measures the magnitude of the bias of the negatively biased expert referee. We assume that the referee’s bias magnitude \( b \) is common knowledge.\(^\text{15}\)

Given these assumptions, we obtain the following conditional probabilities regarding a negatively biased expert referee’s reporting strategy:

\[
P(m_H | G) = P(s_H | G)P(m_H | s_H) + P(s_L | G)P(m_H | s_L) = p_2(1 - b),
\]

(19)

\[
P(m_H | B) = P(s_H | B)P(m_H | s_H) + P(s_L | B)P(m_H | s_L) = (1 - p_2)(1 - b).
\]

(20)

Then, the unconditional probability of the editor receiving a positive report from a negatively biased

\(^{15}\)In practice, editors may not know the bias of potential expert referees; they may only have a prior probability assessment regarding this bias. Modeling expert referees’ bias in this manner introduces considerable additional complexity into the model without generating commensurate insights.
expert referee is given by:  

\[ P(m_H) = P(G)P(m_H | G) + P(B)P(m_H | B) = (1 - b)\left[g p_2 + (1 - g)(1 - p_2)\right]. \]  

(21)

After receiving a report from a negatively biased expert referee, the editor revises his belief about the quality of the paper using Bayesian updating. If the editor receives a positive referee report \((m = m_H)\) from a negatively biased expert referee, his posterior belief that the paper is of good quality, denoted by \(\hat{g}_H^n\), is given by:

\[ \hat{g}_H^n \equiv P(G | m_H) = \frac{g p_2}{g p_2 + (1 - g)(1 - p_2)}. \]  

(22)

Since \(p_2 > 0.5\), it follows that \(\hat{g}_H^n > g\).  

If the editor receives a negative referee report \((m = m_L)\), his posterior belief that the paper is of good quality, denoted by \(\hat{g}_L^n\), is given by:

\[ \hat{g}_L^n \equiv P(G | m_L) = \frac{g[p_2 b + (1 - p_2)]}{g[p_2 b + (1 - p_2)] + (1 - g)[(1 - p_2) b + p_2]}. \]  

(23)

It follows that \(\hat{g}_L^n < g\) since \(p_2 > 0.5\) and \(0 < b < 1\).  

Similar to the earlier case of the generalist referee discussed in Section 3.1, the editor’s ex-ante expected payoff from employing a negatively biased expert referee can be expressed as follows:

\[ P(m_H) \cdot \max\{0, \hat{g}_H R - (1 - \hat{g}_H) L\} + P(m_L) \cdot \max\{0, \hat{g}_L^n R - (1 - \hat{g}_L^n) L\} - c. \]  

(24)

The editor will accept a paper with a positive report and reject one with a negative report from a negatively biased expert referee, if his prior belief \(g\) about the paper falls in the interval characterized by the unconditional probability \(P(m_L)\) of the editor receiving a negative referee report from a negatively biased expert referee is \([1 - P(m_H)]\), which is equal to \(g[p_2 b + (1 - p_2)] + (1 - g)[(1 - p_2) b + p_2]\).  

Note that conditional on receiving a positive report from a negatively biased expert referee, the editor’s posterior belief \(\hat{g}_H^n\) about the quality of the paper is not affected by the bias \(b\) of the referee.

Conditional on receiving a negative report from a negatively biased expert referee, the editor’s posterior belief \(\hat{g}_L^n\) about the quality of the paper is affected by the bias \(b\) of the referee. In his Bayesian updating, the editor accounts for the possibility that the negatively biased referee may have submitted a negative report even after generating a positive private signal about the quality of the paper.
by the following inequality:\textsuperscript{19}

\[
\frac{(1 - p_2)L}{p_2R + (1 - p_2)L} < g \leq \frac{(p_2 + (1 - p_2)b)L}{(p_2 + (1 - p_2)b)L + ((1 - p_2) + p_2b)R}.
\] (25)

Thus, if the editor’s prior $g$ falls in this interval, he will solicit a referee report from a negatively biased expert referee provided that the cost of refereeing is sufficiently small. Then, the editor’s expected payoff from employing a negatively biased expert referee given in (24) simplifies to:

\[
P(m_H) \cdot [\hat{g}_H^n R - (1 - \hat{g}_H^n)L] - c = (1 - b)[gp_2 R - (1 - g)(1 - p_2)L] - c.
\] (26)

The following proposition characterizes the editor’s optimal refereeing decision when only a negatively biased expert referee is available to him.

**Proposition 2 (Editor’s choice between desk acceptance, desk rejection, and a negatively biased expert referee)** Let $c < (1 - b)(2p_2 - 1)\frac{LR}{L + R}$. Suppose that there only exists the negatively biased expert referee with bias $b$. If the editor’s prior probability assessment $g$ about the quality of the paper is low, so that $0 < g \leq k_2$, it is optimal for the editor to desk-reject the paper. If the editor’s prior probability assessment $g$ about the quality of the paper is moderate, so that $k_2 < g < s_2$, it is optimal for the editor to request a report from a negatively biased expert referee. If the editor’s prior probability assessment $g$ about the quality of the paper is very high, so that $s_2 \leq g < 1$, it is optimal for the editor to desk-accept the paper.

The intuition behind the above proposition is as follows. First, consider the case when the editor’s prior assessment about the paper is less than or equal to the threshold $\bar{g}$ ($g \leq \bar{g}$). In this case, if the editor does not employ a referee, he will desk-reject the paper since $gR - (1 - g)L \leq 0$. Thus, ex ante, the editor will choose to employ a negatively biased expert referee, if and only if his expected payoff from employing a negatively biased expert referee is greater than the zero payoff he receives from desk rejection:

\[
(1 - b)(gp_2 R - (1 - g)(1 - p_2)L) - c > 0.
\] (27)

We can equivalently express this condition as a restriction on the prior belief $g$ of the editor. Thus, if

\textsuperscript{19}The editor will reject a paper after receiving a negative referee report on it from a negatively biased expert referee if and only if his posterior $\hat{g}_L^n$ is below the threshold $\bar{g}$ ($\hat{g}_L^n \leq \bar{g}$). Further, he will accept a paper for which he receives a positive report from a positively biased expert referee if and only if $\hat{g}_H^n > \bar{g}$.}
$g < \bar{g}$, the editor will prefer desk rejection to employing a negatively biased expert referee if and only if the following condition holds:

$$0 < g \leq k_2 = \frac{c_b + (1 - p_2)L}{p_2R + (1 - p_2)L}.$$ 

(28)

Therefore, if $k_2 < g \leq \bar{g}$, the editor will optimally choose to send the paper to the negatively biased expert referee rather than desk-reject it based on his prior.

Second, let $g \geq \bar{g}$. In this case, if the editor does not employ a referee, he will desk-accept the paper based on his prior belief, since $gR - (1 - g)L > 0$. Thus, ex ante, the editor will choose to send the paper to the expert referee, if and only if the following condition holds:

$$(1 - b)[gp_2R - (1 - g)(1 - p_2)L] - c > gR - (1 - g)L.$$ 

(29)

Once again, we can equivalently express this condition as a restriction on the prior belief $g$ of the editor. Thus, if $g > \bar{g}$, the editor will prefer desk acceptance to employing a negatively biased expert referee if and only if the following condition holds:

$$s_2 = \frac{(p_2 + b(1 - p_2))L - c}{(p_2 + b(1 - p_2))L + (1 - p_2 + bp_2)R} \leq g < 1.$$ 

(30)

Thus, if $\bar{g} < g < s_2$, the editor will optimally choose to send the paper to the negatively biased expert referee rather than simply desk-accept it based on his prior.

### 3.3 The Expert Referee with a Positive Bias

As mentioned earlier in this section, an expert referee may also be positively biased with respect to certain papers. This may arise for different reasons. One potential way in which such a positive bias may arise is that a referee may be favorably inclined toward papers that support his school of thought (e.g., papers empirically confirming hypotheses originally put forward by him). In this subsection, we will analyze the case when an editor faces a positively biased expert referee alone.

After reviewing the paper, a positively biased expert referee will generate a binary private signal $s$ ($s = s_H$ or $s = s_L$) with the properties given in (17) with respect to a negatively biased expert referee.
Thus, a positively biased expert referee’s signal about the quality of the paper is as precise and informative as that of a negatively biased expert referee. Symmetric to our modeling for a negatively biased expert referee, we assume that a positively biased expert referee will adopt the following (biased) reporting strategy after obtaining his signal $s$:

$$P(m = m_H \mid s_H) = 1, \quad P(m = m_L \mid s_L) = 1 - b. \quad (31)$$

Thus, if a positively biased expert referee receives a negative private signal ($s = s_L$) about the paper, he reports it truthfully ($m = m_L$) only with probability $(1 - b)$. In other words, he issues a positive report ($m = m_H$) with probability $b$ (where $0 < b < 1$), whenever he receives a negative signal. On the other hand, if he receives a positive signal ($s = s_H$), he reports it truthfully ($m = m_H$) with probability 1.

Given these assumptions, if the editor receives a positive referee report ($m = m_H$) from a positively biased expert referee, his posterior belief that the paper is of good quality, $\hat{g}_H^p$, is given by:21

$$\hat{g}_H^p = P(G \mid m_H) = \frac{g \left[p_2 + (1 - p_2)b\right]}{g \left[p_2 + (1 - p_2)b\right] + (1 - g) \left[1 - p_2\right] + p_2b}. \quad (32)$$

On the other hand, if the editor receives a negative referee report ($m = m_L$) from a positively biased expert referee, his posterior belief that the paper is of good quality, $\hat{g}_L^p$, is given by:22

$$\hat{g}_L^p = P(G \mid m_L) = \frac{g(1 - p_2)}{g(1 - p_2) + (1 - g)p_2}. \quad (33)$$

The editor will accept a paper with a positive report and reject one with a negative report from a positively biased expert referee, if his prior belief $g$ about the paper falls in the interval characterized

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20We also assume that the magnitude $b$ of the positively biased expert referee’s bias is common knowledge.
21The unconditional probability $P(m_H)$ of the editor receiving a positive report from a positively biased expert referee is equal to $g \left[p_2 + (1 - p_2)b\right] + (1 - g) \left[1 - p_2\right] + p_2b$. The unconditional probability $P(m_L)$ of the editor receiving a negative referee report from a positively biased expert referee is $1 - P(m_H)$, which is equal to $(1 - b)\left[g(1 - p_2) + (1 - g)p_2\right]$. 22Note that since $p_2 > 0.5$ and $0 < b < 1$, it follows that $\hat{g}_H^p > g$. It also follows that $\hat{g}_L^p < g$ since $p_2 > 0.5$. 21
by the following inequality:\(^{23}\)

\[
\frac{(1 - p_2) + bp_2) L}{(p_2 + b(1 - p_2)) R + ((1 - p_2) + bp_2) L} < g \leq \frac{p_2 L}{p_2 L + (1 - p_2) R} .
\]  

(34)

In summary, if the editor’s prior \(g\) falls in the interval characterized by (34), the editor will solicit a referee report from a positively biased expert referee, provided that the cost of refereeing is sufficiently small. Then, the editor’s expected payoff from employing a positively biased expert referee is given by:\(^{24}\)

\[
P(m_H) \cdot [\hat{g}_H^p R - (1 - \hat{g}_H^p)L] - c = g \left[ p_2 + (1 - p_2)b \right] R - (1 - g) \left[ (1 - p_2) + p_2b \right] L - c .
\]  

(35)

4 The Editor’s Choice among a Positively Biased Expert Referee, a Negatively Biased Expert Referee, and a Generalist Referee

In this section, we allow the editor to select one referee from three different types of candidate referees: a generalist referee, an expert referee with a positive bias of size \(b\), and an expert with negative bias of size \(b\).\(^25\) We will then characterize the conditions under which the editor decides to send the paper to one referee rather than desk-reject or desk-accept it and his optimal choice among the three different types of referees.

First, we analyze the editor’s choice between a generalist referee and a negatively biased expert referee to review a paper. From Propositions 1 and 2, it follows that if the editor’s prior belief \(g\) about the quality of the paper is in a certain range (i.e., in the interval \([\max\{k_1, k_2\}, \min\{s_1, s_2\}]\)), he will prefer employing either a negatively biased expert or a generalist referee to desk-rejection or

\(^{23}\)Similar to the cases of a generalist referee and a negatively biased expert referee, the editor will reject a paper after receiving a negative referee report on it from a positively biased expert referee if and only if his posterior \(\hat{g}_L^p\) is below the threshold \(\bar{g} (\hat{g}_L^p \leq \bar{g})\). Further, he will accept a paper for which he receives a positive report from a positively biased expert referee if and only if \(\hat{g}_H^p > \bar{g}\).

\(^{24}\)While we have developed a proposition characterizing an editor’s choice between desk rejection or acceptance, and a positively biased expert referee, we will not present it here due to space limitations, since it is symmetric with the result presented in Proposition 2 (the results are available to interested readers upon request). We will revisit the case of a positively biased expert referee in more detail in the next section, where we analyze the editor’s choice between desk acceptance or rejection, a generalist referee, a positively biased expert referee, and a negatively biased expert referee.

\(^{25}\)For simplicity, we assume that the symmetric case where both the positively biased and the negatively biased expert referee available to the editor have the same bias magnitude. If we allow the two types of expert referees to have different bias magnitudes, the general nature of our results does not change, though the thresholds on the editor’s prior that characterize his choices across the three types of referees will change.
acceptance. In this case, the editor will compare his expected utility from employing a negatively biased expert referee to his expected utility from employing a generalist referee, and will decide which type of referee will review the paper. The editor will choose the negatively biased expert referee over the generalist referee, if and only if the following condition holds:

\[(1 - b)(gp_2R - (1 - g)(1 - p_2)L) \geq gp_1R - (1 - g)(1 - p_1)L.\]  

(36)

Otherwise, he will choose to send the paper to the generalist referee. We can rearrange the inequality (36) to solve for the cut-off value \(g_n\) of the prior belief \(g\), at which the editor is indifferent between the generalist referee and the negatively biased expert referee:

\[g_n = \frac{(p_2 - p_1 + b(1 - p_2))L}{b(p_2R + (1 - p_2)L) - (p_2 - p_1)(R - L)}.\]  

(37)

If we take the difference between the signal precision of the negatively biased expert referee and that of the generalist referee, which is equal to \(p_2 - p_1\), as given, we can then analyze how the editor’s choice between a generalist referee and a negatively biased expert referee changes as the magnitude of the bias \(b\) of the negatively biased expert referee increases from 0 to 1.

If the negatively biased expert referee has a very small amount of bias, i.e., if \(0 \leq b < b_1\), one can show that the generalist referee will be dominated by the expert referee for all values of his prior belief \(g\), where the editor finds optimal to employ a negatively biased expert referee rather than make a desk decision (see Proposition 2), i.e., if \(g \in (k_2, s_2)\). Moreover, if \(0 \leq b < b_1\), the following relationship holds:

\[k_2 < k_1 < \bar{g} < s_1 < s_2 < g_n.\]  

(38)

If the bias is in this range, the cut-off value \(g_n\) is greater than the upper threshold value \(s_1\), above which the editor prefers desk acceptance to employing a generalist referee. As the bias magnitude \(b\) increases, \(s_2\) decreases and \(k_2\) increases monotonically, whereas the generalist referee’s threshold values of \(k_1\) and \(s_1\) do not vary with the bias size \(b\). The threshold value of the bias, \(b_1\), at which the cut-off

\[26\text{Thus, if the bias magnitude is small, the range of values of the prior belief } g, \text{ where the editor prefers the generalist referee to desk rejection or acceptance, i.e., } (k_1, s_1), \text{ is a subset of the range of values of } g, \text{ i.e., } (k_2, s_2), \text{ where the editor prefers the negatively biased expert referee to desk rejection or acceptance.}\]
value \( g_n \) is equal to both \( s_1 \) and \( s_2 \), is given by:

\[
b_1 = \frac{(p_2 - p_1)(LR - c(R - L))}{(p_1 + p_2 - 1)LR - c(p_2R + (1 - p_2)L)}.
\]

(39)

The trade-off between the more precise signal of the negatively biased expert referee and his bias is most relevant, when this bias is relatively moderate, so that \( b_1 \leq b \leq b_2 \). In this case, the following relationship holds:

\[
k_2 < k_1 < \hat{g} < s_2 < s_1.
\]

(40)

Further, the cut-off value \( g_n \) of the editor’s prior belief will lie in the closed interval \([k_1, s_1]\), if and only if \( b_1 \leq b \leq b_2 \). Thus, if \( b_1 \leq b \leq b_2 \) and \( g_n < g < s_1 \), the editor will prefer to employ the generalist referee rather than the negatively biased expert referee to review the paper, since, in that range, the cost of the expert’s bias will outweigh the benefit from his more precise signal about the quality of the paper. On the other hand, if \( b_1 \leq b \leq b_2 \) and \( k_2 < g \leq g_n \), the editor will still prefer the negatively biased expert referee, since, ex ante, the benefit from his more precise signal will exceed the cost of his biased refereeing.

The intuition as to why the generalist referee becomes the editor’s more preferred choice, when his prior belief \( g \) is above a certain cut-off value \( g_n \), can be explained as follows. As the average quality of a paper in the population increases, so that the prior belief \( g \) about the quality of any paper increases, the editor expects that the negative bias of the expert referee against papers with good quality potential will become a more serious problem in the editorial process. In other words, as \( g \) increases, type I errors (rejection of good papers) will be more likely to be committed on average by negatively biased expert referees due to their negative bias against papers which are highly likely to be of good quality. Therefore, if \( b_1 \leq b \leq b_2 \) and \( g_n < g \leq s_1 \), the editor will prefer to employ the generalist referee rather than the negatively biased expert referee to review the paper.

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27 The threshold value \( b_1 \) is defined by the equality of the threshold values \( s_1 \) and \( s_2 \) of the generalist referee and the negatively biased expert referee respectively. Thus, if \( b = b_1 \), the upper threshold values \( s_1 \) and \( s_2 \) for the generalist and the negatively biased expert referees are equal to each other, and both of these values are equal to the cut-off value \( g_n \) for the prior belief \( g \) of the editor, at which the editor is indifferent between the negatively biased expert referee and the generalist referee. Hence, it follows that if \( b = b_1 \) and \( g = g_n \), the editor can send the paper to either the generalist referee or the negatively biased expert referee. However, if \( b = b_1 \) and \( k_2 < g < g_n = s_1 = s_2 \), the editor will still prefer the negatively biased expert referee to the generalist referee.

28 The threshold value \( g_n \) is monotonically decreasing in the size of the bias \( b \). If \( b = b_2 \), we have \( g_n = k_1 = k_2 < s_2 < s_1 \), and if \( k_1 < g \leq s_1 \), the editor will prefer the generalist referee to the negatively biased expert referee.
Once the bias $b$ of the expert referee crosses a threshold $b_2$, which is given by:

$$b_2 = \frac{(p_2 - p_1)(LR + c(R - L))}{(p_2 - p_1)LR + c(p_2R + (1 - p_2)L)}.$$  \hspace{1cm} (41)

the editor will find that the generalist referee will totally dominate the negatively biased expert referee. This will be the case, because the expert referee’s bias will be extremely high for any level of the editor’s prior belief $g$. Moreover, if $b > b_2$, the following relationship will hold:

$$g_n < k_1 < k_2 < \bar{g} < s_2 < s_1,$$  \hspace{1cm} (42)

so that the cut-off value $g_n$ is less than the lower threshold value $k_1$, below which the editor prefers desk rejection to employing a generalist referee.\footnote{The threshold bias value $b_2$ is defined by the equality of the editor’s lower prior threshold values $k_1$ and $k_2$ for the generalist referee and the negatively biased expert referee respectively. Further, if $b = b_2$, it holds that $k_1 = k_2 = g_n$.}

Next, we consider the editor’s choice between a positively biased expert referee and a generalist referee. One can show that if $g \in [\max\{k_1, k_3\}, \min\{s_1, s_3\}]$, the editor prefers employing either a positively biased expert or a generalist referee to desk rejection or desk acceptance.\footnote{Note that if the negatively biased expert referee’s bias is very high ($b > b_2$), the range of values of the prior belief $g$, where the editor prefers the expert referee to desk rejection or acceptance, i.e., $(k_2, s_2)$, is a subset of the range of values of $g$, i.e., $(k_1, s_1)$, where the editor prefers the generalist referee to desk rejection or acceptance.} In this case, the editor will prefer the positively biased expert referee over the generalist referee if and only if his prior belief $g$ is greater than the cut-off value $g_p$, which is given by:

$$g_p = \frac{(p_1 - (1 - b)p_2)L}{(p_2 - p_1 + b(1 - p_2))R + (p_1 - (1 - b)p_2)L}.$$  \hspace{1cm} (43)

Analogous to the threshold value $b_1$ (given by (39)) of the bias $b$ of a negatively biased expert referee, if the bias of the positively biased expert referee is smaller than a threshold value $b_3$, which is given by

$$b_3 \equiv \frac{(p_2 - p_1)(LR + c(R - L))}{LR(p_1 + p_2 - 1) - c(p_2L + (1 - p_2)R)},$$  \hspace{1cm} (44)

the editor will prefer the positively biased expert referee to the generalist for any level of his prior belief $g$ in

\footnote{Similar to the threshold values $k_2$ and $s_2$ that were defined earlier for a negatively biased expert referee, the threshold values $k_3$ and $s_3$ are defined for a positively biased expert referee. They characterize the editor’s decision between employing a positively biased expert referee and desk rejection or acceptance. If $g \in (k_3, s_3)$, the editor prefers to employ a positively biased expert referee rather than desk-reject or desk-accept the paper.}
the range \((k_3, s_3)\).

Analogous to the threshold value \(b_2\) (given by (41)) of the bias \(b\) of a negatively biased expert referee, above which the editor will choose a generalist referee, we can also derive a similar threshold for the bias \(b\) of a positively biased expert referee, which is given by:

\[
b_4 \equiv \frac{(p_2 - p_1)(LR - c(R - L))}{(p_2 - p_1)LR + c(p_2L + (1 - p_2)R)}, \tag{45}
\]

above which the editor will prefer the generalist referee to the positively biased expert referee for any level of his prior belief \(g\) in the range \((k_1, s_1)\).\(^{32}\)

The editor’s expected payoff from employing a positively biased expert referee will be greater than his expected payoff from employing a negatively biased expert referee, if and only if the following condition is satisfied:

\[
g(p_2 + b(1 - p_2))R - (1 - g)((1 - p_2) + bp_2)L \geq (1 - b)(gp_2R - (1 - g)(1 - p_2)L). \tag{46}
\]

After simplifying this condition, we find that it is equivalent to the following simple condition:

\[
g \geq \bar{g} = \frac{L}{L + R}. \tag{47}
\]

The editor prefers the positively biased expert to the negatively biased expert if his prior belief is sufficiently high \((g \geq \bar{g})\), and prefers a negatively biased expert to a positively biased expert if his prior belief is low \((g < \bar{g})\).\(^{33}\)

**Proposition 3 (The Editor’s choice between desk acceptance, desk rejection, a generalist referee, a positively biased expert referee, and a negatively biased expert referee)** Let \(c < \min\{(2p_1 - 1), (1 - b)(2p_2 - 1)\} \cdot \frac{LR}{L + R}\).

(i) If the bias \(b\) of the expert referees is relatively small, so that \(0 \leq b \leq \tilde{b} \equiv \frac{2(p_2 - p_1)}{2p_2 - 1}\), the editor’s optimal policy is as follows: if the editor’s prior belief \(g\) about the paper is extremely low, so that \(0 < g \leq k_2\), the editor desk-rejects the paper. If his prior belief is moderately low, so that \(k_2 < g \leq \bar{g}\), the editor sends the paper to the expert referee with negative bias. If his prior belief is sufficiently high, the editor will choose the generalist referee.\(^{34}\)

\(^{32}\)The cut-off value \(g_p\) of the editor’s prior belief lies in the closed interval \([k_1, s_1]\), if and only if \(b_3 \leq b \leq b_4\). Moreover, \(g_p\) is monotonically increasing in the size of the bias \(b\).

\(^{33}\)One should note that this condition does not depend on the size of the bias \(b\), which is the same for both the positively biased and the negatively biased expert referee.

\(^{34}\)If the bias \(b\) of the expert referees is relatively small, so that \(0 \leq b \leq \tilde{b} \equiv \frac{2(p_2 - p_1)}{2p_2 - 1}\), the editor’s optimal policy is as follows: if the editor’s prior belief \(g\) about the paper is extremely low, so that \(0 < g \leq k_2\), the editor desk-rejects the paper. If his prior belief is moderately low, so that \(k_2 < g \leq \bar{g}\), the editor sends the paper to the expert referee with negative bias. If his prior belief is sufficiently high, the editor will choose the generalist referee.
is moderately high, so that \( \bar{g} < g < s_3 \), he sends the paper to the expert referee with positive bias. If his prior belief is extremely high, so that \( s_3 \leq g \leq 1 \), he desk-accepts the paper.

(ii) If the bias \( b \) of the expert referees is moderately large, so that \( \bar{b} < b < \min\{b_2, b_4\} \), the editor’s optimal policy is as follows: if the editor’s prior belief \( g \) about the paper is very low, so that \( 0 < g \leq k_2 \), the editor desk-rejects the paper. If \( k_2 < g \leq g_p \) (where \( g_p \) is given in (A.9)), the editor sends the paper to the generalist referee. If his prior belief is very high, so that \( g_p < g < s_3 \), he sends the paper to the expert referee with positive bias. If his prior belief is extremely high, so that \( s_3 \leq g \leq 1 \), he desk-accepts the paper.

(iii) (a) If \( R > L \) and the bias \( b \) of the expert referees is very large, so that \( b_2 \leq b < b_4 \), the editor’s optimal policy is as follows: if the editor’s prior belief \( g \) about the paper is very low, so that \( 0 < g \leq k_1 \), the editor desk-rejects the paper. If \( k_1 < g \leq g_p \), the editor sends the paper to the generalist referee. If \( g_p < g < s_3 \), the editor sends the paper to the expert referee with positive bias. If his prior belief is very high, so that \( s_3 \leq g \leq 1 \), he desk-accepts the paper.

(b) If \( R < L \) and the bias \( b \) of the expert referees is very large, so that \( b_4 \leq b < b_2 \), the editor’s optimal policy is as follows: if the editor’s prior belief \( g \) about the paper is very low, so that \( 0 < g \leq k_2 \), the editor desk-rejects the paper. If \( k_2 < g \leq g_n \), the editor sends the paper to the expert referee with negative bias. If \( g_n \leq g < s_1 \), the editor sends the paper to the generalist referee. If his prior belief is very high, so that \( s_1 \leq g < 1 \), he desk-accepts the paper.

(iv) If the bias \( b \) of the expert referees is extremely large, so that \( \max\{b_2, b_4\} \leq b < 1 \), the editor’s optimal policy is as follows: if the editor’s prior belief \( g \) about the paper is very low, so that \( 0 < g \leq k_1 \), the editor desk-rejects the paper. If his prior belief is moderate, so that \( k_1 < g < s_1 \), the editor sends the paper to the generalist referee. If his prior belief is very high, so that \( s_1 \leq g \leq 1 \), he desk-accepts the paper.

Part (i) of this proposition shows that if the bias of either type of expert referee is not very large so that \( b < \bar{b} \), the editor’s optimal choice is between the positively biased expert and the negatively biased expert for moderate values of the prior belief \( g \). If \( b < \bar{b} \), we can show that the following inequality will always hold:

\[
g_p < \bar{g} < g_n. \tag{48}\]

In this case, if the editor’s prior belief \( g \) is less than the threshold \( \bar{g} \), he prefers a negatively biased expert referee to a generalist referee since \( g < \bar{g} < g_n \); however, if \( g > \bar{g} \), he prefers a positively biased expert to a generalist since \( g_p < \bar{g} < g \). From (47), we also know that the editor prefers a positively biased expert to a negatively biased one if and only if \( g > \bar{g} \). Note that, in this range of \( b \) (i.e., \( b < \bar{b} \)) where the expert referees’ bias is relatively small, the editor never chooses to send the paper to a generalist referee.
The size of the expert referee bias \( b \)

The editor’s prior belief \( g \)

Desk acceptance region

Desk rejection region

Pick a generalist referee

Pick a positively biased expert referee

Pick a negatively biased expert referee

\[ \bar{b} = 0.2593 \]

\[ b_2 = 0.8528 \]

\[ b_4 = 0.8277 \]

Part (ii) of the above proposition analyzes the case where the bias of the expert referees is moderately large. As the size of the bias \( b \) increases, the editor’s preference for expert referees against a generalist referee diminishes. If \( b \) is large enough that \( \bar{b} < b < \min\{ b_2, b_4 \} \), the following inequality holds:\(^{34}\)

\[ g_n \leq \bar{g} \leq g_p. \]  \hspace{1cm} (49)

In this case, for moderate values of his prior belief \( g \), i.e., \( g_n \leq g \leq g_p \), the editor prefers the generalist referee over both types of expert referees. In summary, when the expert referees’ bias is moderately

\(^{34}\)If \( b = \bar{b} \), it follows that \( g_n = \bar{g} = g_p \).
large, the editor chooses desk rejection, a negatively biased expert referee, a generalist referee, a 
positively biased expert referee, or desk acceptance as his prior belief regarding the paper moves from 
very low to very high.

Part (iii) of the above proposition shows that if the journal’s editorial policy exhibits a preference 
for minimizing type I errors over minimizing type II errors (in other words, the gain $R$ to the editor 
from accepting good papers is higher than his loss $L$ from accepting bad papers), it holds that $b_2 < b_4$. 
In that case, if the expert referee bias $b$ takes a value between $b_2$ and $b_4$, the editor makes his optimal 
choice between a positively biased expert referee and a generalist referee, completely eliminating the 
negatively biased expert referee from consideration. On the other hand, if the journal’s editorial policy 
exhibits a preference of minimizing type II errors over minimizing type I errors (i.e., $R < L$) it holds 
that $b_4 < b_2$. In this case, if the expert referee bias $b$ takes a value between $b_4$ and $b_2$, the editor makes 
his optimal choice between a negatively biased expert referee and a generalist referee, completely 
eliminating the positively biased expert referee from consideration.

Finally, part (iv) the above proposition shows that, when the size of the expert referee bias is large 
足够的 that it crosses a threshold value given by the maximum of $b_2$ and $b_4$, the generalist referee 
totally dominates both types of expert referees regardless of the prior belief of the editor about the 
paper. Once the bias of the expert referees is very large, the advantage arising from the higher precision 
of the expert referee’s signal over that of the generalist referee is swamped by the large expert bias, 
so that the editor will no longer choose to use an expert referee regardless of his prior belief about the 
paper. In summary, when the bias of expert referees is very large, the editor chooses desk rejection, 
a generalist referee, or desk acceptance as his prior belief regarding the paper goes from very low to 
very high. Figure 2 illustrates a numerical example based on Proposition 3.

5 The Case of Two Referees

In this section, we allow the editor to send the paper to two referees simultaneously. Each referee will 
draw an independent private signal $s$ about the quality of the paper, and he will send back his referee 
report $m$ to the editor based on his true signal and his bias. While generalist referees have no bias 
($b = 0$), their private signals are less precise than those of expert referees: $p_2 > p_1 > 0.5$. Expert
referees have either a positive or a negative bias, and the magnitude \( b \) of the bias is the same for each expert referee. The direction and the size of each expert referee’s bias is common knowledge. We assume that the editor can send a given paper to one of the following combinations of two referees: a) two generalist referees; b) two positively biased expert referees; c) two negatively biased expert referees; d) two oppositely biased expert referees.\(^{35}\) The fixed cost of employing two referees is \( 2c \).

The editor will aggregate the information he obtains from two referee reports to form his posterior belief about the quality of the paper using Bayesian updating. As in the case of a single referee, he will either accept or reject the paper based on his expected payoff from accepting the paper conditional on his posterior belief.

### 5.1 Two Generalist Referees

Let’s first consider the case of two generalist referees. Both referees will truthfully reveal their signals: \( m_1 = s_1 \) and \( m_2 = s_2 \). If the editor receives two positive referee reports (\( m_1 = m_H \) and \( m_2 = m_H \)), his posterior belief that the paper is of good quality is given by

\[
\hat{g}_{HH} = \Pr(G \mid m_H, m_H) = \frac{gp_1^2}{gp_1^2 + (1-g)(1-p_1)^2}.
\]

Note that since \( p_1 > 0.5 \), it follows that when the editor receives two positive reports from two generalist referees, he updates his prior belief to a higher value than when he receives only one positive referee report (in the case of a single generalist referee): i.e., \( \hat{g}_{HH} > \hat{g}_H \). Therefore, the editor will accept the paper if gets two positive referee reports.

If the editor receives two negative referee reports (\( m_1 = m_L \) and \( m_2 = m_L \)), his posterior belief that the paper is of good quality is given by

\[
\hat{g}_{LL} = \Pr(G \mid m_L, m_L) = \frac{g(1-p_1)^2}{g(1-p_1)^2 + (1-g)p_1^2}.
\]

Since \( p_1 > 0.5 \), we can verify that receiving two negative reports from two generalist referees is more

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\(^{35}\)Another possible combination consists of a generalist referee and a biased expert referee (either positively biased or negatively biased). For simplicity, we do not consider this combination in our analysis since it doesn’t generate any significant insights commensurate with its additional complexity. The analysis of this case is available to interested readers upon request.
informative for the editor than receiving only one negative referee report: i.e., \( \hat{g}_{LL} < \hat{g}_L \). Therefore, the editor will reject the paper if he gets two negative referee reports.

Finally, if the editor receives a combination of one positive report and one negative report from the two generalist referees, his posterior belief that the paper is of good quality will be equal to his prior belief:

\[
\hat{g}_{HL} = P(G | m_L, mL) = \frac{gp_1(1 - p_1)}{gp_1(1 - p_1) + (1 - g)(1 - p_1)p_1} = g. 
\]  

Thus, in the case of two generalist referees, receiving two referee reports with opposite views about the quality of the paper is not informative for the editor. The editor will then accept the paper only if his prior belief \( g \) is sufficiently high, i.e., if \( g > \bar{g} \); he rejects the paper if \( g \leq \bar{g} \).

The editor’s ex-ante expected payoff from employing two generalist referees can be expressed as follows:

\[
P(m_{HH}) \cdot (\hat{g}_{HH}R - (1 - \hat{g}_{HH})L) + 2P(m_{HL}) \cdot \max\{0, gR - (1 - g)L\} - 2c. 
\]  

Given this objective function, the editor will prefer two generalist referees to desk rejection if the following condition holds:

\[
g \geq k_{gg} \equiv \frac{(1 - p_1)^2L + 2c}{p_1^2R + (1 - p_1)^2L}. 
\]  

Similarly, the editor will prefer two generalist referees to desk acceptance if the following condition holds:

\[
g \leq s_{gg} \equiv \frac{p_1^2L - 2c}{p_1^2L + (1 - p_1)^2R}. 
\]

**Proposition 4 (Two Generalist Referees versus One Generalist Referee)** Suppose that \( k_{gg} \leq g \leq s_{gg} \), so that the editor prefers sending the paper to two generalist referees to desk-rejecting or desk-accepting it. The editor will prefer to employ two generalist referees instead of one generalist referee alone if the following conditions hold:

(i) When the editor’s prior belief \( g \) is low so that \( g < \hat{g} \), two generalist referees will be preferred to one generalist referee alone if

\[
c < p_1(1 - p_1)((1 - g)L - gR). 
\]  

(ii) When the editor’s prior belief \( g \) is high so that \( g > \hat{g} \), two generalist referees will be preferred to one generalist referee alone if

\[
c < p_1(1 - p_1)(gR - (1 - g)L). 
\]
The above proposition shows that the editor will trade off the marginal benefit from receiving a more precise aggregate signal about the paper quality from using an additional referee against the marginal cost of employing a second referee. Note that the above conditions (56) and (57) are more likely to hold if the fixed cost $c$ of employing a referee is sufficiently low and if the signal precision $p_1$ of one generalist referee alone is not too large. The marginal benefit from having a second generalist referee will be significant only if the signal precision of a single generalist referee is not too large.

5.2 Two Negatively Biased Expert Referees

In the case of two negatively biased expert referees, we assume that each referee follows the reporting strategy we assumed above in the case of a single negatively biased expert referee. In other words, based on their independently drawn private signals, each expert referee reports his signal truthfully only if it is negative. However, a referee draws a positive signal about the quality of the paper, he follows a mixed strategy and reports his signal truthfully only with probability $(1 - b)$.

If the editor receives two positive referee reports $(m_{n,1} = m_H$ and $m_{n,2} = m_H)$ from two negatively biased experts, his posterior belief that the paper is of good quality is given by:

$$
\hat{g}^{nn}_{HH} \equiv P(G \mid m_H, m_H) = \frac{gp_2^2}{gp_2^2 + (1 - g)(1 - p_2)^2}.
$$

(58)

On the other hand, if the editor receives two negative reports $(m_{n,1} = m_L$ and $m_{n,2} = m_L)$ from two negatively biased expert referees, his posterior belief that the paper is of good quality is given by:

$$
\hat{g}^{nn}_{LL} \equiv P(G \mid m_L, m_L) = \frac{g(p_2b + 1 - p_2)^2}{g(p_2b + 1 - p_2)^2 + (1 - g)((1 - p_2)b + p_2)^2}.
$$

(59)

Since $\hat{g}^{nn}_{LL} < g$, the editor adjusts his prior belief $g$ about the paper downward after receiving two negative referee reports regardless of the size of the bias $b$. Further, for a large range of values for the parameters $b$ and $p_2$, we can show that $\hat{g}^{nn}_{LL} < \bar{g}$, and therefore the editor rejects the paper after receiving two negative reports in this case.

If the editor receives a combination of one positive report and one negative report from two

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Note that the bias term $b$ does not factor in this posterior probability, since the editor infers that two positive reports from two negatively biased expert referees must be unbiased.
negatively biased experts, his posterior belief that the paper is of good quality is given by:

\[ \hat{g}^{nn}_{HL} \equiv P(G \mid m_H, m_L) = \frac{g p_2 (p_2 b + 1 - p_2)}{g p_2 (p_2 b + 1 - p_2) + (1 - g)(1 - p_2)((1 - p_2)b + p_2)}. \]  

(60)

Receiving only one positive referee report from two negatively biased expert referees is informative for the editor in the sense that he updates his prior belief \( \hat{g}^{nn}_{HL} \) upward: i.e., \( \hat{g}^{nn}_{HL} > g \). In this case, the editor will accept the paper if his posterior belief \( \hat{g}^{nn}_{HL} \) is sufficiently high so that \( \hat{g}^{nn}_{HL} R - (1 - \hat{g}^{nn}_{HL}) L > 0 \). This is equivalent to the following condition in terms of the editor’s prior belief \( g \):

\[ g > \bar{g}^{nn} = \frac{(1 - p_2)((1 - p_2)b + p_2)L}{(1 - p_2)((1 - p_2)b + p_2)L + p_2(p_2 b + 1 - p_2)R}, \]  

(61)

where \( \bar{g}^{nn} < \bar{g} \).

The editor’s ex-ante expected payoff from employing two negatively biased expert referees can be expressed as follows:

\[ P(m^{nn}_{HH}) \cdot (\hat{g}^{nn}_{HH} R - (1 - \hat{g}^{nn}_{HH}) L) + 2P(m^{nn}_{HL}) \cdot \max\{0, \hat{g}^{nn}_{HL} R - (1 - \hat{g}^{nn}_{HL}) L\} - 2c. \]  

(62)

Given this objective function, the editor will prefer two negatively biased expert referees to desk rejection if the following condition holds:

\[ g \geq k^{nn} = \frac{(1 - p_2)^2 L + \frac{2c}{(1 - b)^2}}{p_2 R + (1 - p_2)^2 L}. \]  

(63)

Similarly, the editor will prefer two negatively biased expert referees to desk acceptance if the following condition holds:

\[ g \leq s^{nn} = \frac{(p_2 + b(1 - p_2))^2 L - 2c}{(p_2 + b(1 - p_2))^2 L + (1 - p_2 + b p_2)^2 R}. \]  

(64)

### 5.3 Two Positively Biased Expert Referees

In the case of two positively biased expert referees, we assume that each referee follows the reporting strategy we assumed above in the case of a single positively biased expert referee. In other words, each referee reports his independently drawn private signal truthfully (with probability 1) only if it
is positive. However, if a referee draws a negative signal about the quality of the paper, he follows a mixed strategy and reports his signal truthfully only with probability \((1 - b)\).

If the editor receives two positive referee reports \((m_{p,1} = m_H\) and \(m_{p,2} = m_H\)) from two positively biased experts, his posterior belief that the paper is of good quality is given by:

\[
\hat{g}_{pp}^{HH} \equiv P(G \mid m_H, m_H) = \frac{g(p_2 + b(1 - p_2))^2}{g(p_2 + b(1 - p_2))^2 + (1 - g)(1 - p_2 + bp_2)^2}. \tag{65}
\]

If the editor receives two negative reports \((m_{p,1} = m_L\) and \(m_{p,2} = m_L\)) from two positively biased expert referees, his posterior belief that the paper is of good quality is given by:

\[
\hat{g}_{pp}^{LL} \equiv P(G \mid m_L, m_L) = \frac{g(1 - p_2)^2}{g(1 - p_2)^2 + (1 - g)p_2^2}. \tag{66}
\]

Since \(\hat{g}_{pp}^{LL} < g\), the editor adjusts his prior belief \(g\) about the paper downward after receiving two negative referee reports, and rejects the paper since \(\hat{g}_{pp}^{LL} < \bar{g}\).

If the editor receives a combination of one positive report and one negative report from two positively biased experts, his posterior belief that the paper is of good quality is given by:

\[
\hat{g}_{pp}^{HL} \equiv P(G \mid m_H, m_L) = \frac{g(p_2 + b(1 - p_2))(1 - p_2)}{g(p_2 + b(1 - p_2))(1 - p_2) + (1 - g)(1 - p_2 + bp_2)p_2}. \tag{67}
\]

Receiving only one positive referee report from two positively biased expert referees is informative for the editor in the sense that he updates his prior belief \(g\) downward: i.e., \(\hat{g}_{pp}^{HL} < g\). In this case, the editor will accept the paper if his posterior belief \(\hat{g}_{pp}^{HL}\) is sufficiently high so that \(\hat{g}_{pp}^{HL}R - (1 - \hat{g}_{pp}^{HL})L \geq 0\). This is equivalent to the following condition in terms of the editor’s prior belief \(g\):

\[
g \geq \tilde{g}_{pp} \equiv \frac{p_2(1 - p_2 + bp_2)L}{p_2(1 - p_2 + bp_2)L + (1 - p_2)(p_2 + b(1 - p_2))R}, \tag{68}
\]

where \(\tilde{g}_{pp} > \bar{g}\).

The editor’s ex-ante expected payoff from employing two positively biased expert referees can be
expressed as follows:

\[
P(m_{HH}^p) \cdot (g_{HH}^p R - (1 - g_{HH}^p)L) + 2P(m_{HL}^p) \cdot \max\{0, g_{HL}^p R - (1 - g_{HL}^p)L\} - 2c. \tag{69}
\]

Given this objective function, the editor will prefer two positively biased expert referees to desk rejection if the following condition holds:

\[
g \geq k_{pp} \equiv \frac{(1 - p_2 + b p_2)^2 L + \frac{2c}{(1-b)^2}}{(1 - p_2 + b p_2)^2 L + (p_2 + b(1 - p_2))^2 R}. \tag{70}
\]

Similarly, the editor will prefer two positively biased expert referees to desk acceptance if the following condition holds:

\[
g \leq s_{pp} \equiv \frac{p_2^2 L - \frac{2c}{(1-b)^2}}{p_2^2 L + (1 - p_2)^2 R}. \tag{71}
\]

**Proposition 5 (Two Generalist Referees versus Two Expert Referees with the Same Bias)**

(i) If the bias of expert referees is small, so that

\[
b \leq b_{21} \equiv \frac{-d_1 - 4\sqrt{d_1^2 - 4a_1 c_1}}{2a_1}, \tag{72}
\]

where

\[
d_1 = p_2^2 - p_1^2 - 2p_1 p_2 (p_2 - p_1) - 2p_2 (1 - p_2)(2p_2 - 1),
\]

\[
a_1 = p_2 (1 - p_2)(2p_2 - 1),
\]

\[
c_1 = 2p_2 (1 - p_2)(p_2 - p_1),
\]

two generalist referees will be dominated by either two negatively biased expert referees or two positively biased expert referees. In this case, if \(g \leq \bar{g}\), the editor always prefers two negatively biased expert referees to two generalist referees. If \(g > \bar{g}\), the editor prefers two positively biased expert referees to two generalist referees.

(ii) If the bias of expert referees is moderate, so that \(b_{21} < b < b_{31} < \sqrt{\frac{2(p_2 - p_1)}{2p_2 - 1}}\), where \(b_{31}\) is given in (A.25), the editor’s optimal choice between two expert referees with the same type of bias and two generalist referees is as follows. If \(k_{mn} < g \leq g_{mn}^{low}\), the editor chooses to send the paper to two negatively biased expert referees. If \(g_{mn}^{up} \leq g < s_{pp}\), the editor chooses to send the paper to two positively biased expert referees. If \(g_{mn}^{low} < g < g_{mn}^{up}\) or \(g_{nn}^{up} < g < g_{nn}^{up}\), the editor chooses to send the paper to two generalist referees.

(iii) If the bias of expert referees is large, so that

\[
b \geq \sqrt{\frac{2(p_2 - p_1)}{2p_2 - 1}}, \tag{73}
\]

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two generalist referees will dominate both two negatively biased expert referees and two positively
biased expert referees for any prior belief \( g \) of the editor.

The above proposition shows that, in the case of two referees, the editor’s choice between different
combinations of referees is still determined by the trade-off between the benefit gained from the higher
signal precision of expert referees (compared to generalists) versus the loss of information arising from
the higher bias of expert referees. If the size of the bias \( b \) is sufficiently small so that \( b \leq b_{21} \), the editor
finds it optimal to employ expert referees rather than generalist referees. However, if the size of the
expert referees’ bias is large enough that \( b \geq \sqrt{\frac{2(p_2-p_1)}{2p_2-1}} \), the editor prefers to employ two generalist
referees.

Part (i) of the above proposition shows that, if the bias is small enough that \( b \leq b_{21} \), the editor
always prefers two negatively biased experts to two generalist referees when his prior belief about the
quality of the paper is low (\( g \leq \bar{g} \)). On the other hand, he always prefers two positively biased expert
referees to two generalists if his prior belief is high (\( g > \bar{g} \)). Thus, in this case, two generalist referees
are dominated by either negatively biased or positively biased experts, depending on the prior belief of
the editor. Thus, in this range of expert referee bias, the editor never chooses to employ two generalist
referees.

Part (ii) of the above proposition studies the case where the bias of expert referees is moderate,
so that \( b_{21} < b < b_{31} \). In this case, for extremely low prior beliefs and extremely high prior beliefs,
the editor chooses to send the paper to two negatively biased expert referees or two positively biased
expert referees, respectively. For intermediate prior beliefs, where the editor is more uncertain about
the quality of the paper ex ante, the editor chooses to send the paper to two generalist referees. The
intuition here is very similar to that in the single referee case characterized in Proposition 3(ii), where
the editor optimally chooses to send the paper to a negatively biased expert referee for very low prior
beliefs about the paper; to a generalist referee if he has intermediate prior beliefs; and to a positively
biased expert referee if he has high prior beliefs.

Finally, part (iii) of the above proposition studies the case where the bias of expert referees is
very large. In this case, the editor will always choose to send the paper to two generalists regardless
of his prior belief about the paper, since the greater precision of the signals received by experts is
swamped by the information loss due to their bias. The intuition here is again similar to the single
referee case (characterized in Proposition 3(iv)) where the editor chooses a negatively biased expert, a
generalist, or a positively biased expert depending on whether his prior belief about the paper is very
low, intermediate, or very high.

The focus of the above proposition has been on the editor’s choice between two negatively biased
experts, two generalists, or two positively biased experts. However, it can be shown that, for the range
of expert referee bias studied in Proposition 5, the editor will desk-reject the paper for very low prior
beliefs and desk accept the paper for very high prior beliefs, similar to his choice in the single referee
case studied in Proposition 3.

Proposition 6 (Two Expert Referees with the Same Bias versus One Expert Referee) For
any prior belief \( g \) about the paper, there exists a low enough refereeing cost \( c_n(g) \), such that if \( c < c_n(g) \),
the editor will prefer two negatively biased expert referees to a single negatively biased expert referee.
Similarly, for any prior belief \( g \) about the paper, there exists a low enough refereeing cost \( c_p(g) \), such
that if \( c < c_p(g) \), the editor will prefer two positively biased expert referees to a single positively biased
referee.

This proposition shows that, if the editor efficiently processes the information that he collects from
two expert referees with similar bias (i.e., using Bayesian updating) and the marginal cost of sending
the paper to an additional referee is sufficiently small, he will always prefer two expert referees biased
in the same direction to a single expert referee with the same bias. The intuition here is that, when
the editor has perfect information about the size and the direction of each expert referee’s bias, he
can account for the aggregate bias of the two referees when he is forming his posterior belief about the
paper using Bayesian updating, and therefore, the aggregate informativeness of two recommendations
dominates the informativeness of a single recommendation. It is important to note that the above
result holds only under the scenario where the editor can efficiently process the information in the
referees’ recommendations (i.e., using Bayesian updating). We show in Section 6 that this result will
not hold if the editor follows an ad hoc rule in processing referees’ recommendations: e.g., a rule that
both referees have to give a favorable recommendation for a paper to be accepted.

5.4 Two Oppositely Biased Expert Referees

In this subsection, we study the case where the choices available to the editor include two oppositely
biased expert referees: i.e., the editor can choose to send a paper to one positively biased and one
negatively biased expert referee (in addition to the other combinations of two referees discussed in previous subsections: two generalists, two negatively biased experts, or two positively biased experts).

Consider now the case where the editor sends a paper to two expert referees, one with a positive bias and one with a negative bias. If the editor receives two positive referee reports \((m_n,1 = m_H \text{ and } m_p,2 = m_H)\) from the two referees, his posterior belief that the paper is of good quality is given by:

\[
\hat{g}^{np}_{HH} \equiv P(G | m_H, m_H) = \frac{g p_2 (p_2 + b) (1 - p_2)}{g p_2 (p_2 + b) (1 - p_2) + (1 - g) (1 - p_2) (1 - p_2 + bp_2)}.
\] (74)

If the editor receives two negative reports \((m_n,1 = m_L \text{ and } m_p,2 = m_L)\) from the two referees, his posterior belief that the paper is of good quality is given by:

\[
\hat{g}^{np}_{LL} \equiv P(G | m_L, m_L) = \frac{g (1 - p_2 + bp_2) (1 - p_2)}{g (1 - p_2 + bp_2) (1 - p_2) + (1 - g) (p_2 + b (1 - p_2)) p_2}.
\] (75)

If the editor receives a negative report from the negatively biased expert referee and a positive report from the positively biased expert referee \((m_n,1 = m_L \text{ and } m_p,2 = m_H)\), his posterior belief that the paper is of good quality will be equal to his prior belief:

\[
\hat{g}^{np}_{LH} \equiv P(G | m_L, m_H) = \frac{g (1 - p_2 + bp_2) (p_2 + b (1 - p_2))}{(1 - p_2 + bp_2) (p_2 + b (1 - p_2))} = g.
\] (76)

If the editor receives a positive report from the negatively biased expert referee and a negative report from the positively biased expert referee \((m_n,1 = m_H \text{ and } m_p,2 = m_L)\), his posterior belief that the paper is of good quality will be also equal to his prior belief:\(^{37}\)

\[
\hat{g}^{np}_{HL} \equiv P(G | m_H, m_L) = \frac{g (1 - b)^2 p_2 (1 - p_2)}{(1 - b)^2 p_2 (1 - p_2)} = g.
\] (77)

Thus, in the case of two oppositely biased expert referees, receiving two referee reports with

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\(^{37}\)The result that the case of getting a negative report from a positively biased expert and a positive report from a negatively biased expert is as uninformative as the case of getting two expert referee reports in the same direction as their bias (i.e., a negative report from the negatively biased expert and a positive report from the positively biased expert) may initially seem counterintuitive to readers. The intuition here is that, while getting a positive report from a negatively biased expert is more informative (and favorable to the paper) than getting a positive report from a positively biased expert, this effect is canceled out by the fact that getting a negative report from a positively biased expert is also more informative (and unfavorable to the paper) than getting a negative report from a negatively biased expert.
opposite recommendations about the paper is not informative for the editor. In this scenario, the editor will accept the paper only if his prior belief $g$ about the paper is sufficiently high, i.e., if $g \geq \bar{g}$.

The editor’s ex-ante expected payoff from employing two oppositely biased expert referees can be expressed as follows:

$$P(m_{HH}^{np}) \cdot (g_{HH}^{np} R - (1 - g_{HH}^{np}) L) + (P(m_{HL}^{np}) + P(m_{LH}^{np})) \cdot \max\{0, gR - (1 - g)L\} - 2c.$$  (78)

Given this objective function, the editor will prefer two oppositely biased expert referees to desk rejection if the following condition holds:

$$g \geq k_{np} \equiv \frac{(1 - p_2)(1 - p_2 + bp_2)L + \frac{2c}{(1-b)}}{(1 - p_2)(1 - p_2 + bp_2)L + p_2(1 - p_2 + b(1 - p_2))R}.$$  (79)

Similarly, the editor will prefer two oppositely biased expert referees to desk acceptance if the following condition holds:

$$g \leq s_{np} \equiv \frac{p_2(b(1 - p_2))L - \frac{2c}{(1-b)}}{p_2(1 - p_2) + (1 - p_2)(1 - p_2 + bp_2)L + (1 - p_2)(1 - p_2 + bp_2)R}.$$  (80)

**Proposition 7 (Two Expert Referees with Opposite Biases versus Two Generalist Referees)**

(i) If the expert referees’ bias is small, so that

$$b \leq \tilde{b} \equiv \frac{2(p_2 - p_1)}{2p_2 - 1},$$  (81)

then two generalist referees will be dominated by two oppositely biased expert referees regardless of the prior belief of the editor.

(ii) If the expert referees’ bias is moderate so that $\tilde{b} < b < b_{np}$, the editor’s optimal choice between two oppositely biased expert referees and two generalist referees is as follows. If $k_{np} < g \leq g_{np}^{low}$ or $g_{np}^{up} \leq g < s_{np}$, the editor prefers two oppositely biased expert referees to two generalist referees. If $g_{np}^{low} < g < g_{np}^{up}$, the editor prefers two generalist referees to two oppositely biased expert referees.

(iii) If the expert referees’ bias is large, so that

$$b \geq b_{np} \equiv \frac{-d_{np} - 4\sqrt{d_{np}^2 - 4a_{np}c_{np}}}{2a_{np}},$$  (82)
where
\[ d_{np} = (1 - 2p_2) \left( LR \left( p_1^2(1 - p_2) + (1 - p_1)^2p_2 \right) + 2c(Lp_2 - R(1 - p_2)) \right), \]
\[ a_{np} = p_2(1 - p_2) \left( (2p_1 - 1)LR - 2c(L + R) \right), \]
\[ c_{np} = LR(p_1^2(p_2^2 - p_1(2 - p_1)) + (1 - p_1^2)(p_2(2 - p_2) - p_1^2) + 2p_2(1 - p_2)(2p_1 - 1)) \]
\[ + 2cL((1 - p_1^2) - (1 - p_2)^2 - 2p_2(1 - p_2)) + 2cR(p_1(2 - p_1) - p_2^2 - 2p_2(1 - p_2)), \] (83)

then two generalist referees will dominate two oppositely biased expert referees regardless of the prior belief of the editor.

When we compare a combination of two oppositely biased expert referees to a combination of two generalist referees, we again find that there exists a trade-off between the higher informativeness of expert referee signals and the loss of information arising from expert referee bias. If the bias size \( b \) is small enough so that it is less than \( \bar{b} \) (as in part (i)), the editor always chooses to employ two oppositely biased expert referees rather than two generalists. If the size of expert referee bias is moderate so that \( \bar{b} < b < b_{np} \) (as in part (ii) of the above proposition), then the editor’s optimal choice depends on his prior beliefs: for extremely low prior beliefs and extremely high prior beliefs, the editor chooses to send the paper to a pair of oppositely biased expert referees instead of two generalists. For intermediate prior beliefs, where the editor is more uncertain about the quality of the paper ex ante, the editor chooses to send the paper to two generalist referees instead of two oppositely biased expert referees. Finally, if the referee bias is very large so that \( b \geq b_{np} \) (as in part (iii)), the editor always prefers two generalist referees to two oppositely biased expert referees.

**Proposition 8 (The Editor’s Choice among Expert Referees)** Suppose that \( b < \bar{b} = \frac{2(p_2 - p_1)}{2p_2 - 1} \) so that, if the editor chooses to send the paper to two referees, he chooses to send the paper only to expert referees. The editor’s optimal choice among two positively biased expert referees, two negatively biased referees, and two oppositely biased referees is as follows: If the editor’s prior belief \( g \) about the paper is very low, so that \( 0 < g < k_{nn} \), the editor desk-rejects the paper. If \( k_{nn} \leq g \leq g_{np;nn;1} \), where \( g_{np;nn;1} \) is given in (A.34), the editor sends the paper to two negatively biased expert referees. If his prior belief is moderate, so that \( g_{np;nn;1} < g \leq g_{np;pp;1} \), where \( g_{np;pp;1} \) is given in (A.36), or \( g_{np;nn;3} \leq g < g_{np;pp;3} \), where \( g_{np;nn;3} \) and \( g_{np;pp;3} \) are given in (A.39) and (A.37) respectively, then the editor sends the paper to two oppositely biased expert referees. If \( g_{np;pp;3} \leq g \leq s_{pp} \), the editor sends the paper to two positively biased expert referees. If the editor’s prior belief \( g \) about the paper is very high, so that \( g > s_{pp} \), the editor desk-accepts the paper.

This proposition analyzes the editor’s three-way choice among three possible combinations of two expert referees when the bias is less than \( \bar{b} \) (so that two oppositely biased expert referees still dominate
Figure 3: The Editor’s Choice among Expert Referees.

This figure presents a numerical example depicting the intervals of prior beliefs where the editor makes an optimal choice among two positively biased expert referees, two negatively biased referees, and two oppositely biased referees (as explained in Proposition 8). The size of the expert referee bias is 0.30. Other parameter values are: $c = 5$, $R = 300$, $L = 300$, $p_1 = 0.7$, $p_2 = 0.8$. Then, it follows that $\bar{g} = 0.5$, and the specific values of the threshold prior beliefs given in Proposition 8 are as follows: $k_{nn} = 0.159$, $g_{np,nn,1} = 0.200$, $g_{np,pp,1} = 0.338$, $g_{np,nn,3} = 0.662$, $g_{np,pp,3} = 0.800$, and $s_{pp} = 0.841$.

two generalist referees). In this scenario, when the editor’s prior belief $g$ is not too low, i.e., $k_{nn} \leq g \leq g_{np,nn,1}$, so that desk-rejection is not optimal, the editor prefers to send the paper to two negatively biased expert referees. The intuition here is that the negative bias of the expert referees is not too costly to the editor since he has a low prior on the paper. Thus, he can afford to send the paper to two negatively biased expert referees to obtain the small amount of additional information he requires to make a decision about the paper. However, if the editor’s prior belief is moderate so that $g_{np,nn,1} < g < g_{np,pp,3}$, we show that there exist two intervals of prior beliefs $((g_{np,nn,1}, g_{np,pp,1})$ and $(g_{np,nn,3}, g_{np,pp,3})$) where the editor will optimally choose to send the paper to two oppositely biased expert referees. Thus, when the editor himself is very uncertain about the quality of the paper ex ante, he can utilize experts with biases in different directions so as to minimize the information loss which results when the experts have their bias in the same direction. If the editor’s prior is sufficiently high so that $g_{np,pp,3} \leq g \leq s_{pp}$, we show that the editor prefers to send the paper to two positively biased expert referees to obtain the small amount of additional information he requires to make a decision about the paper.

The intuition behind the editor’s choice between two expert referees with the same (i.e., both
positive or both negative) bias versus opposite biases can be seen by analyzing the informativeness of various possible outcomes when the editor chooses two referees with opposite biases versus two referees with the same bias. First consider the outcome of conflicting reports from two referees in the scenario where the editor chooses two referees of opposite bias. As discussed earlier (see equations (76) and (77)), this is the least informative outcome, since the editor’s posterior after reading the referee reports will be the same as his prior under this outcome. Thus, the only informative outcome in the case where the editor chooses two referees of opposing bias occurs when one of the referees gives a recommendation in the same direction as his bias while the other gives a recommendation opposite to his bias with no conflict between the recommendations of the two referees (e.g., both the positively biased referee and the negatively biased referee recommend rejection or both referees recommend acceptance).

Now consider the informativeness of various possible outcomes when the editor chooses two referees with the same bias. Broadly speaking, the three possible outcomes in this scenario are the following: the first outcome involves both referees giving recommendations in the same direction as their bias (e.g., two positively biased referees recommending acceptance); the second outcome involves one referee giving a recommendation in the same direction as his bias with the other giving a recommendation opposite to his bias (e.g., one positively biased referee recommending acceptance while the other recommends rejection); the third outcome involves both referees giving recommendations opposite to their bias (e.g., two negatively biased referees recommending acceptance). In analyzing the informativeness of the above outcomes, we note the following. First, of the above outcomes, the most informative is the one where both referees give recommendations in a direction opposite to their bias. However, this outcome also has the lowest probability of occurring. Second, all of the above three outcomes are informative about paper quality, unlike in the case where the editor chooses two referees of opposite biases, where only one of the three possible outcomes is informative about paper quality. Third, in the scenario where both referees are of the same bias, the outcome where both referees recommend in the same direction as their bias is less informative than the outcome in scenario with two referees of opposite biases where one referee reports against his bias while the other one reports in the same direction as his bias. In summary, the editor’s optimal choice between two expert referees of the same bias versus two expert referees of opposing biases is not unambiguous, and depends on
his prior belief regarding a paper and the bias of expert referees, as we show in Proposition 8. Our analysis in Proposition 8 also demonstrates that the common intuition that choosing two referees of opposing biases always dominates choosing two referees of the same bias (because it allows the editor to filter out the effect of referee bias) is not correct.

Figure 3 illustrates a numerical example based on Proposition 8, and represents the editor’s choice among various combinations of expert referees as a function of the prior probability regarding the quality of the paper.

6 Comparison of Two Expert Referees versus One Expert Referee when the Editor adopts an Ad Hoc Information Processing Rule

We have so far assumed that a journal editor can efficiently process the (potentially biased) information contained in the recommendations of referees using Bayes’ Rule. When the editor forms his posterior belief about a paper using Bayes’ rule, he takes into account both the precision of the referee’s signal and the potential bias of the referee. In practice, however, many journal editors may adopt some ad hoc rules when evaluating referee reports, such as requiring both referees (in the case of two referees) to agree on the acceptance of a paper before it is published. When using such ad hoc rules, the editor may not be able take into account the effect of expert referee bias (positive or negative) on his editorial decisions properly. In this subsection, we analyze the effect of such an ad hoc policy on the journal’s expected payoff, and in particular, on the editor’s choice between one biased expert referee versus two expert referees with biases in the same direction.

Earlier, we showed in Proposition 6 that, under efficient information processing (i.e., with Bayesian updating), two expert referees biased in the same direction always dominate one biased expert referee, provided that the incremental cost of an additional referee is very small. We now assume that the editor adopts the following ad hoc rule instead of using Bayesian updating: in the case of one expert referee only, he accepts the paper if and only if the referee submits a positive recommendation; in the case of two expert referees, the editor will accept the paper if and only if both expert referees give positive recommendations.\(^{38}\)

\(^{38}\)The empirical literature on peer review has raised the question whether requiring agreement among reviewers inhibits
Proposition 9 (The Editor’s Choice between Two Expert Referees versus One Expert Referee under an Ad Hoc Rule) Let the marginal cost of sending the paper to a second referee be zero. If the editor adopts an ad hoc rule that requires all referees of a given paper to issue positive recommendations before it is published, the choice between two biased expert referees versus one biased expert referee is as follows:

(i) The editor will choose one negatively biased expert referee if $g > \bar{g}_{nn}$, where $\bar{g}_{nn}$ is given by (61); he will choose two negatively biased expert referees if $g \leq \bar{g}_{nn}$.

(ii) The editor will choose one positively biased expert referee if $g > \bar{g}_{pp}$, where $\bar{g}_{pp}$ is given by (68); he will choose two positively biased expert referees if $g \leq \bar{g}_{pp}$.

(iii) The threshold prior belief $\bar{g}_{nn}$ is decreasing in $b$, whereas the threshold prior belief $\bar{g}_{pp}$ is increasing in $b$. Further, $\bar{g}_{nn} < \bar{g} = \frac{L}{L+R} < \bar{g}_{pp}$.

The above proposition shows that, if the editor uses the ad hoc rule described above, there are regions of prior belief $g$ where the editor is better off using only one biased expert referee instead of two biased expert referees. Further, under the given ad hoc rule, the deviation from the efficient Bayesian outcome becomes larger in the case of two negatively biased expert referees as the negative bias $b$ increases. In contrast, the ad hoc rule becomes closer to the efficient rule in the case of two positively biased expert referees as the positive bias $b$ increases. Note that the above result is asymmetric with respect to the bias of positive versus negatively biased expert referees since the ad hoc acceptance rule is biased in favor of rejecting papers (relative to the outcome given in the situation where editors process information using Bayes’ rule).

7 The Strategic Reporting Model

Earlier, we assumed that an expert referee was endowed with the direction and magnitude of his bias, so that this bias was a fixed parameter in our model. Further, we assumed that the editor does not produce any information about the paper on his own (beyond that required to form his prior beliefs). In this section, we allow the expert referee and the editor to interact strategically so that the expert referee’s bias is endogenously determined in equilibrium. We now assume that an expert referee is endowed only with the direction of his bias (positive or negative), and the magnitude of this bias is strategically chosen by him. Thus, the referee optimally chooses his bias probability $b$ in equilibrium.
The paper is submitted. The referee chooses his bias probability. The editor determines the amount of resources to be devoted to generate his own signal.

The editor decides to desk reject or desk accept or request a referee report. If he requests a referee report, he chooses the nature of referee.

After receiving a referee report and generating his own independent signal, the editor forms his posterior belief using Bayesian updating.

Final acceptance or rejection of the paper.

If a report is requested, the referee submits a report.

Figure 4: Sequence of Events in the Strategic Reporting Model.

In this setup, we assume that a negatively biased referee obtains a private benefit of $B$ when he makes an unfavorable report about a paper that he is negatively biased about, and obtains a benefit of 0 by reporting favorably. Similarly, a positively biased referee obtains a private benefit of $B$ from making a favorable report on a paper that he is positively biased about, and obtains a benefit of 0 when he conveys an unfavorable report.

We further assume that the editor has a technology that allows him to obtain an additional noisy signal (a good signal $E_G$ or a bad signal $E_B$) about the intrinsic quality of the paper by exerting an effort level $w$:

$$P(E_G \mid G) = 1 - r = P(E_B \mid B). \quad (84)$$

The noise (or error) probability in the editor’s technology is denoted by $r$, and it is a decreasing function of the editor’s effort level $w$:

$$r = r(w) \equiv (1 - p_1) - aw. \quad (85)$$

where $a$ is the editor’s ability level. Thus, the noise of the editor’s signal, $r$, is linear and decreasing in the editor’s effort level $w$. Further, the more able “$a$” the editor is, the more productive he is in
terms of reducing the noise $r$ in his signal. The editor’s error probability $r$ for a given effort level $w$ is decreasing in the editor’s ability parameter $a$: in other words, achieving a certain reduction in error probability $r$ will be less costly for an editor if his ability parameter $a$ is higher.\textsuperscript{39} The maximum value of $r$ is given by $r(0) = 1 - p_1$ and its minimum possible value is given by $r(\bar{w}) = r_{\text{min}}$. In other words, the editor generates an independent private signal about the intrinsic quality of the paper, which is at least as precise as a generalist referee’s signal, and he can improve the precision of this signal by exerting an additional amount of effort $w$. However, he can eliminate the noise in his signal only down to a lower limit $r_{\text{min}}$ by exerting a maximum level of effort $\bar{w}$. Thus, the relationship between $r_{\text{min}}$ and the editor’s ability $a$ is given by: $r_{\text{min}} = (1 - p_1) - a\bar{w}$. The editor has a quadratic technology cost function, which gives the editor’s cost of exerting effort $w$ and takes the following form:

$$C(w) = W_0(1 + w^2) = W_0 \left(1 + \left(\frac{1 - p_1 - r}{a}\right)^2\right).$$

Further, we assume that if a referee is “caught” giving an unreasonable (or “biased”) report by the editor (as assessed by the editor based on his own signal about the paper), the editor can impose a penalty on him. However, the editor is aware that, in addition to depending on the referee’s bias, sometimes his private signal may disagree with that of the referee due to the noise in his own (i.e., the editor’s) signal or due to the noise in the referee’s signal. Therefore, the penalty imposed by the editor on the referee when their signals disagree, will account for these factors as well: the larger the magnitude $b$ of the referee’s bias and the more precise the editor’s technology (i.e., the lower the noise probability $r$), the higher the expected penalty that the editor imposes on a referee who submits a biased report. Reflecting the above assumptions, we assume that the editor imposes a penalty $b(1 - r)K$ on any referee whose report on a paper differs from his own signal ($E_G$ or $E_B$), in the direction of the referee’s bias. If the referee report is opposite to the referee’s bias, the editor will not impose a penalty on him, even if his own signal disagrees with the referee’s report. In this setup, the referee chooses his bias strategically, trading off his expected benefit from biased reporting against the cost of getting caught by the editor when he submits a biased report.

In this strategic reporting model, for analytical simplicity, we focus only on the case where the

\textsuperscript{39}Note that equation (85) can be equivalently expressed as $w = \frac{(1-p_1) - r}{a}$. 

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editor always chooses to have the paper refereed: i.e., we do not allow for desk rejection or desk acceptance.

7.1 Strategic Reporting by a Negatively Biased Expert Referee

In this subsection, we study the case where the only type of referee available to an editor is a negatively biased expert referee.\(^{40}\)

Given the editor’s strategy choice of \(w\) (and therefore, \(r\)), a negatively biased expert referee chooses his bias \(b\) to maximize the following objective

\[
\max_b \left[ (gp_2 + (1 - g)(1 - p_2))b + g(1 - p_2) + (1 - g)p_2]B - [(gp_2(1 - r) + (1 - g)(1 - p_2)r)b + g(1 - p_2)(1 - r) + (1 - g)p_2r]b(1 - r)K, \right. \tag{87}
\]

From the first order condition of this maximization problem, the negatively biased expert referee’s strategic choice of his bias as a function of the editor’s noise probability \(r\) is given by:

\[
b(r) = \frac{[gp_2 + (1 - g)(1 - p_2)]B - [g(1 - p_2)(1 - r) + (1 - g)p_2r](1 - r)K}{2[gp_2(1 - r) + (1 - g)(1 - p_2)r](1 - r)K}. \tag{88}
\]

The form of the negatively biased expert referee’s bias function implies that the editor can induce the referee to choose a lower bias probability \(b\) by exerting a higher level of effort \(w\), i.e., the bias probability \(b\) is a decreasing function of the editor’s effort \(w\), or equivalently, it is an increasing function of the editor’s noise probability \(r\) for a large range of parameter values: \(\frac{\partial b}{\partial r} > 0\). By increasing his signal to noise ratio (i.e., by reducing \(r\)), the editor not only gets a more precise independent signal of his own, but also increases the probability of a referee being punished when he submits a biased report. This, in turn, reduces the referee’s incentive to send biased referee reports, thereby leading him to choose a lower bias probability \(b\).

The editor incorporates both the expert referee’s recommendation as well as his own evaluation of the paper in deciding whether to accept or reject a paper. He will update his prior belief about the

\(^{40}\)In the case of strategic reporting by a positively biased referee, the strategy space of the editor and the expert referee are very similar to those in the case of strategic reporting by a negatively biased referee except the direction of the referee’s bias, which is common knowledge. Therefore, due to space limitations, we omit this analysis (available to interested readers upon request) here.
paper based on both the referee’s (potentially negatively biased) report and his own private signal. If the editor and the referee both have positive evaluations of the paper, we denote this event as \( m_{HH} \). If the editor has a positive evaluation of the paper, but the referee submits a negative report, we denote this event as \( m_{HL} \) and so on. The editor’s ex-ante expected payoff can be expressed as follows:

\[
P(m_{HH}) \cdot (\bar{g}_{HH}R - (1 - \bar{g}_{HH})L) + P(m_{HL}) \cdot \max\{0, \bar{g}_{HL}R - (1 - \bar{g}_{HL})L\}
+ P(m_{LH}) \cdot \max\{0, \bar{g}_{LH}R - (1 - \bar{g}_{LH})L\} - c - W_0(1 + w^2).
\]

If the editor’s prior belief \( g \) is sufficiently high (and for the range of parameter values where the referee’s conjectured equilibrium bias \( b \) is also high), the editor will override a negative recommendation from the expert referee based on his Bayesian-updated posterior belief if his own independent signal is positive.\(^{41}\) In this case, by rearranging the above objective function, we can see that the editor will choose his noise probability \( r \) to solve the following maximization problem:

\[
\max_r (1 - b)[g(1 - r)p_2R - (1 - g)r(1 - p_2)L]
+ g(1 - r)p_2(bp_2 + 1 - p_2)R - (1 - g)r(b(1 - p_2) + p_2)L
+ (1 - b)[gp_2R - (1 - g)(1 - r)(1 - p_2)L] - c - W_0 \left(1 + \left(1 - \frac{p_1 - r}{a}\right)^2\right).
\]

The first order condition to this maximization problem yields the following best response function of the editor:

\[
r(b) = (1 - p_1) - \frac{a^2}{2W_0}[g(1 - p_2)R + (1 - g)p_2L] - \frac{a^2}{2W_0}[gp_2R + (1 - g)(1 - p_2)L]b.
\]

The editor’s noise function \( r(b) \), which is linear and decreasing in the referee’s bias probability \( b \), implies that if the editor’s conjecture of the referee’s bias probability is greater, the editor reacts by increasing his effort to produce a more informative private signal about the paper, thereby increasing his likelihood of punishing a negatively biased expert referee when he submits his (potentially negatively biased) report.

\(^{41}\) As we discuss in the second paragraph under Proposition 10, we can explicitly characterize the editor’s equilibrium behavior regarding the disposition of the paper only for this range of parameter values so that we focus on these cases in the rest of the paper.
Proposition 10 (The Equilibrium of the Strategic Reporting Game with a Negatively Biased Expert Referee) In the Bayesian Nash equilibrium of the strategic reporting game, the bias probability of a negatively biased expert referee is given by

\[ b^* = \frac{(1 - p_1) - \frac{a^2}{2W_0}(g(1 - p_2)R + (1 - g)p_2L) - r^*}{\frac{a^2}{2W_0}(gp_2R + (1 - g)(1 - p_2)L)}. \]  

(92)

The editor exerts an equilibrium effort level \( w^* \), which is given by

\[ w^* = \frac{1 - p_1 - r^*}{a}. \]  

(93)

The equilibrium noise probability \( r^* \) of the editor’s information production technology is given in (A.46) as the unique real solution to the following cubic equation:

\[(a_{12} - a_{11})r^3 + (a_r a_{11} + a_9 b_7 - a_7 a_{12} - a_{10} b_7 + 2a_{11} - a_{12})r^2 \]
\[+ (a_7 a_{12} + a_{10} b_7 - 2(a_7 a_{11} + a_9 b_7) - a_{11})r + a_7 a_{11} + a_9 b_7 - a_8 b_7 = 0, \]

(94)

where the parameters of this equation are defined in (A.45) in the Appendix.

In equilibrium, the bias level chosen by the referee depends on his conjecture about the effort level that will be exerted by the editor to independently evaluate the paper (and therefore the noise level in the editor’s evaluation, which corresponds inversely with his effort level). At the same time, the effort level chosen by the editor depends on his conjecture regarding the bias level chosen by the referee in his report. Both the above conjectures (the referee’s conjecture about the editor’s effort and the editor’s conjecture about the referee’s bias) are proven correct in equilibrium.

In choosing his equilibrium level of bias, the referee trades off his expected private benefit from sending a biased report against the expected cost of being punished by the journal editor who updates his prior belief about the paper using both the referee’s report and his own private signal that he generates at the cost of exerting some additional effort. The benefit of the editor generating an additional signal is the following. The editor not only receives an additional signal about the paper, but equally important, he induces the referee to substantially reduce his bias in equilibrium (since the referee takes into account the negative consequences of sending a biased report arising from the penalty he will incur in case he is detected by the editor).

For the case where the editor’s prior belief about the paper is high and the equilibrium bias chosen by the negatively biased expert referee is also significant, we can explicitly characterize the editor’s
optimal decision regarding the disposition of the paper as a function of the referee’s recommendation and the editor’s own additional private signal on the paper.\textsuperscript{42} In this range of parameter values, if the negatively biased referee recommends a rejection, but the editor’s own private signal on the paper is good, he will accept the paper (overriding the referee’s recommendation). This is because the editor’s updated posterior belief based on his own prior, the referee’s report, and his additional private signal is such that his expected payoff from accepting the paper will be higher than that from rejecting it. On the other hand, if the negatively biased expert referee recommends accepting the paper, but the editor’s own private signal on the paper is bad, he will accept the paper. In this latter scenario, the editor’s updated belief based on his own prior, the referee’s report, and his additional private signal will be such that his expected payoff from accepting the paper will be higher than that from rejecting it (recall that a negatively biased expert referee’s recommendation is much more informative when his recommendation goes against his own bias). Finally, if the editor’s private signal agrees with the referee’s recommendation (to accept or to reject), he will act according to that recommendation.

In the equilibrium existing for the above range of parameter values, the editor imposes a penalty \( b^*(1 - r^*)K \) on the negatively biased expert referee whenever the referee recommends rejection, but the editor obtains a good private signal on the paper. He imposes such a penalty even though he is aware that disagreement between his own signal and the referee’s recommendation could be due to pure noise rather than due to the referee’s bias: he accounts for this possibility by calibrating the penalty he imposes on the referee in such a way that it is increasing in the referee’s conjectured bias and decreasing in the noise in his own private signal (as discussed earlier).

\subsection{7.2 Comparative Statics}

In this subsection, we analyze the effect of various parameters in our strategic reporting model on the equilibrium bias chosen by a negatively biased expert referee and the equilibrium effort level chosen by the editor.

\textbf{Proposition 11 (Comparative Statics)} In the Bayesian Nash equilibrium of the strategic reporting game, the referee’s bias probability \( b^* \) and the editor’s error probability \( r^* \) are decreasing in the editor’s

\textsuperscript{42}While we do not give here the threshold value of the model parameters for which this type of equilibrium exists, it is available to interested readers upon request.
ability parameter $a$. Further, the referee’s bias probability $b^*$ is increasing in the size of the referee’s private benefit $B$ and decreasing in the parameter $K$ of the penalty imposed by the editor on the referee.

Earlier we defined the parameter $a$, which measures the ability of the editor. The editor’s error probability $r$ for a given effort level $w$ is decreasing in the editor’s ability parameter $a$: in other words, achieving a certain reduction in error probability $r$ will be less costly for an editor if his ability parameter $a$ is higher. Consequently, the editor’s equilibrium error probability $r^*$ is indeed decreasing in $a$, since more able editors will choose to exert a larger amount of effort $w$ in equilibrium (given that their effort is more productive in reducing the noise in their private signal about the paper). As a result, the editor can induce the referee to reduce his bias probability $b^*$ to a greater extent in equilibrium, and thereby receive better (more objective) referee reports. Further, ceteris paribus, as the size of the referee’s private benefit $B$ from sending a negative recommendation increases, this tilts the referee to choosing a higher value of his bias probability $b$. Finally, as the size of the penalty parameter $K$ that the editor imposes on the referee increases, the referee is induced to send biased reports with a lower probability (since this increases the referee’s cost of getting punished for sending biased reports to the editor).

7.3 The Editor’s Choice between a Negatively Biased Expert Referee and a Generalist Referee in the Strategic Reporting Model

In this subsection, we present our analysis of the editor’s choice of referees in our strategic reporting model, allowing the editor to choose between a generalist and a negatively biased expert referee. Since the derivation of the equilibrium quantities in our strategic model involves a high degree of mathematical complexity, we obtain numerical solutions of our model in order to determine the editor’s choice between a negatively biased expert referee and a generalist referee.43

When we allow the editor to interact with a generalist referee in our strategic reporting model, he will still have an incentive to exert some effort $w$ to generate more precise information about the paper, even though his information production has no bias reduction effect. In this case, the editor will trade off the marginal benefit of more information against the cost of producing that information.

43Since the editor’s choice between a positively biased expert referee and a generalist referee is a mirror image of this, we only present our results as they relate to the editor’s choice between a negatively biased expert referee and a generalist referee due to space limitations.
When he faces a generalist referee, the editor chooses his optimal noise probability $r$ to maximize the following objective function:

$$\max_r g(1 - r)p_1 R - (1 - g)r(1 - p_1)L + g(1 - r)(1 - p_1)R - (1 - g)rp_1 L + grp_1 R - (1 - g)(1 - r)(1 - p_1)L - c - W_0 \left(1 + \left(\frac{1 - p_1 - r}{a}\right)^2\right).$$  \hfill (95)

The first order condition to this maximization problem yields the following solution:

$$r = (1 - p_1) - \frac{a^2}{2W_0}(g(1 - p_1)R + (1 - g)p_1 L).$$ \hfill (96)

The editor’s equilibrium choice when dealing with a generalist referee is much simpler than when he deals with a negatively biased expert referee, since he knows that the generalist has no bias and always reports his evaluation of the paper truthfully to him. Thus, the editor makes a decision on the paper using his updated posterior belief based on his own prior, the generalist referee’s recommendation, and his own additional private signal. Further, if the editor’s prior belief about a paper is sufficiently high, this means that the editor will accept a paper if either the generalist referee’s recommendation is to accept or the editor’s own private signal on the paper is good (or both). This is because the editor’s expected payoff based on his updated posterior belief from accepting the paper will be higher than that from rejecting it.

The editor’s equilibrium behavior when dealing with a negatively biased expert referee and the equilibrium behavior of such a referee are as characterized in Proposition 10, even when the editor has a choice between such a referee and a generalist (as is the case in this subsection). We will therefore not discuss it further here.

We now present numerical simulations illustrating the editor’s choice between a generalist and a negatively biased expert referee in our strategic reporting model. The parameter values we use in these simulations are such that the equilibrium behavior of the editor and the negatively biased expert referee are as described in Proposition 10 and that of the generalist referee is as in the equilibrium discussed above (in this subsection). In the numerical simulations presented below, we vary one parameter at a time, keeping the values of all other model parameters fixed at their base case values.
Numerical Results with $R = 500$, $p_1 = 0.70$, $p_2 = 0.80$, $B = 40$, $K = 80$, $r_{\text{min}} = 0.23$, $\bar{w} = 2.3$.

<table>
<thead>
<tr>
<th>$g$</th>
<th>Negatively Biased Expert</th>
<th>Generalist</th>
<th>Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$b$</td>
<td>$r$</td>
<td>$w$</td>
</tr>
<tr>
<td>0.60</td>
<td>0.2856</td>
<td>0.2752</td>
<td>0.8151</td>
</tr>
<tr>
<td>0.61</td>
<td>0.2880</td>
<td>0.2751</td>
<td>0.8175</td>
</tr>
<tr>
<td>0.62</td>
<td>0.2904</td>
<td>0.2750</td>
<td>0.8200</td>
</tr>
<tr>
<td>0.63</td>
<td>0.2927</td>
<td>0.2750</td>
<td>0.8225</td>
</tr>
<tr>
<td>0.64</td>
<td>0.2950</td>
<td>0.2749</td>
<td>0.8249</td>
</tr>
<tr>
<td>0.65</td>
<td>0.2972</td>
<td>0.2748</td>
<td>0.8273</td>
</tr>
</tbody>
</table>

Table 1: The Effect of the Editor’s Prior Belief about Paper Quality on the Choice of Referee.

The last column in each vertical panel in the various tables gives the values of the editor’s objective if he chooses a negatively biased expert referee or a generalist respectively, with the very last column of the table marked “difference” giving the value of the editor’s objective if he chooses a negatively biased expert minus that of his objective if he chooses a generalist. Consequently, if the difference is positive, the editor chooses a negatively biased expert referee in equilibrium; if it is negative, he chooses a generalist referee. In the base case, we assume that the parameters take the following values: $g = 0.62$, $R = 500$, $L = 250$, $p_1 = 0.70$, $p_2 = 0.80$, $B = 40$, $K = 80$, $r_{\text{min}} = 0.23$, $\bar{w} = 2.3$. We first analyze the effect of the editor’s prior belief on the choice between a negatively biased expert referee and a generalist referee.

The results presented in Table 1 show that as the prior belief of the editor about the paper quality increases, he is more likely to choose a generalist referee over a negatively biased expert referee. Ceteris paribus, as the editor’s prior belief increases, the editor is more likely to disagree with a negatively biased expert and therefore, exert costly effort in equilibrium. Hence, if he has a high prior belief about the paper, the editor will be better off by sending the paper to an objective generalist referee as in the basic model with one referee.

The results presented in Table 2 show that as the signal precision of the negatively biased expert referee increases, the editor is more likely to choose a negatively biased expert referee over a generalist referee. Ceteris paribus, as the expert’s signal becomes more informative, the editor can tolerate the negative bias of the expert referee to a greater extent. However, if the signal of the expert referee is not sufficiently more informative than that of the generalist, the editor will choose to send the paper
to the generalist referee rather than the expert referee.

The results presented in Table 3 show that as the private benefit $B$ of the expert referee from sending negative referee reports increases, the editor is more likely to choose a generalist referee over a negatively biased expert referee. This is because as the absolute size of the private benefit from sending a negative referee report increases, the expert referee has a stronger incentive to report in a biased manner in equilibrium. Hence, for larger values of $B$, the editor will be better off by sending the paper to a generalist referee.

The results presented in Table 4 show that as the penalty parameter $K$ imposed by the editor on the negatively biased expert referee when they disagree increases, the editor is more likely to choose a negatively biased expert referee over a generalist referee. If the editor or the journal he works for can potentially enforce a larger penalty to a referee who is believed to be negatively biased in his referee report, the expert referee will strategically be less biased in equilibrium, and therefore, his referee reports will be more informative. The penalty that can be imposed on the referee can potentially be large if the journal already has a good reputation, so that it is a journal that a referee would like to submit his own papers to.

The results in Table 5 and 6 show that, if the editor is more able, that is, he can efficiently extract more information from reading the paper himself at a lower personal cost, the editor is more likely to choose a negatively biased expert referee over a generalist referee to evaluate the paper.\footnote{Note that from (85), it follows that the editor’s ability parameter $a$ can be expressed as a function of $r_{\text{min}}$ and $\bar{w}$: $a = \frac{1-p_1-r_{\text{min}}}{\bar{w}}$.}

The results in Table 5 show that as the editors minimum noise probability $r_{\text{min}}$ decreases, the editor

<table>
<thead>
<tr>
<th>$p_2$</th>
<th>Negatively Biased Expert</th>
<th>Generalist</th>
<th>Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$b$</td>
<td>$r$</td>
<td>$w$</td>
</tr>
<tr>
<td>0.77</td>
<td>0.2777</td>
<td>0.2749</td>
<td>0.8248</td>
</tr>
<tr>
<td>0.78</td>
<td>0.2820</td>
<td>0.2750</td>
<td>0.8232</td>
</tr>
<tr>
<td>0.79</td>
<td>0.2863</td>
<td>0.2750</td>
<td>0.8216</td>
</tr>
<tr>
<td>0.80</td>
<td>0.2904</td>
<td>0.2750</td>
<td>0.8200</td>
</tr>
<tr>
<td>0.81</td>
<td>0.2945</td>
<td>0.2751</td>
<td>0.8184</td>
</tr>
<tr>
<td>0.82</td>
<td>0.2985</td>
<td>0.2751</td>
<td>0.8167</td>
</tr>
</tbody>
</table>

Table 2: The Effect of the Expert Referee’s Signal Precision on the Choice of Referee.

Numerical Results with $R = 500$, $g = 0.62$, $p_1 = 0.70$, $B = 40$, $K = 80$, $r_{\text{min}} = 0.23$, $\bar{w} = 2.3$. 52
Numerical Results with $R = 500, g = 0.62, p_1 = 0.70, p_2 = 0.80, K = 80, r_{min} = 0.23, \bar{w} = 2.3$.

<table>
<thead>
<tr>
<th>B</th>
<th>Negatively Biased Expert</th>
<th>Generalist</th>
<th>Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>35</td>
<td>0.2269 0.2770 0.7555</td>
<td>0.2969 0.1008 225.10</td>
<td>3.92</td>
</tr>
<tr>
<td>37</td>
<td>0.2524 0.2762 0.7813</td>
<td>0.2969 0.1008 225.10</td>
<td>2.52</td>
</tr>
<tr>
<td>40</td>
<td>0.2904 0.2750 0.8200</td>
<td>0.2969 0.1008 225.10</td>
<td>0.45</td>
</tr>
<tr>
<td>41</td>
<td>0.3031 0.2747 0.8328</td>
<td>0.2969 0.1008 225.10</td>
<td>-0.24</td>
</tr>
<tr>
<td>43</td>
<td>0.3283 0.2739 0.8584</td>
<td>0.2969 0.1008 225.10</td>
<td>-1.61</td>
</tr>
<tr>
<td>45</td>
<td>0.3534 0.2731 0.8839</td>
<td>0.2969 0.1008 225.10</td>
<td>-2.96</td>
</tr>
</tbody>
</table>

Table 3: The Effect of the Size of the Expert Referee’s Private Benefit on the Choice of Referee.

Numerical Results with $R = 500, g = 0.62, p_1 = 0.70, p_2 = 0.80, B = 40, r_{min} = 0.23, \bar{w} = 2.3$.

<table>
<thead>
<tr>
<th>K</th>
<th>Negatively Biased Expert</th>
<th>Generalist</th>
<th>Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>74</td>
<td>0.3313 0.2738 0.8615</td>
<td>0.2969 0.1008 225.10</td>
<td>-1.77</td>
</tr>
<tr>
<td>76</td>
<td>0.3170 0.2742 0.8470</td>
<td>0.2969 0.1008 225.10</td>
<td>-1.00</td>
</tr>
<tr>
<td>78</td>
<td>0.3034 0.2746 0.8332</td>
<td>0.2969 0.1008 225.10</td>
<td>-0.26</td>
</tr>
<tr>
<td>80</td>
<td>0.2904 0.2750 0.8200</td>
<td>0.2969 0.1008 225.10</td>
<td>0.45</td>
</tr>
<tr>
<td>82</td>
<td>0.2781 0.2754 0.8075</td>
<td>0.2969 0.1008 225.10</td>
<td>1.12</td>
</tr>
<tr>
<td>84</td>
<td>0.2663 0.2758 0.7955</td>
<td>0.2969 0.1008 225.10</td>
<td>1.76</td>
</tr>
</tbody>
</table>

Table 4: The Effect of the Absolute Size of Penalty imposed by the Editor on the Choice of Referee.

Numerical Results with $R = 500, g = 0.62, p_1 = 0.70, p_2 = 0.80, B = 40, K = 80, \bar{w} = 2.3$.

<table>
<thead>
<tr>
<th>$r_{min}$</th>
<th>Negatively Biased Expert</th>
<th>Generalist</th>
<th>Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.245</td>
<td>0.2981 0.2844 0.6504</td>
<td>0.2981 0.0792 224.93</td>
<td>-0.85</td>
</tr>
<tr>
<td>0.240</td>
<td>0.2957 0.2815 0.7074</td>
<td>0.2977 0.0864 224.98</td>
<td>-0.44</td>
</tr>
<tr>
<td>0.235</td>
<td>0.2931 0.2784 0.7640</td>
<td>0.2974 0.0936 225.04</td>
<td>-0.01</td>
</tr>
<tr>
<td>0.230</td>
<td>0.2904 0.2750 0.8200</td>
<td>0.2969 0.1008 225.10</td>
<td>0.45</td>
</tr>
<tr>
<td>0.225</td>
<td>0.2876 0.2715 0.8755</td>
<td>0.2965 0.1080 225.17</td>
<td>0.93</td>
</tr>
<tr>
<td>0.220</td>
<td>0.2846 0.2676 0.9304</td>
<td>0.2960 0.1152 225.24</td>
<td>1.44</td>
</tr>
</tbody>
</table>

Table 5: The Effect of the Minimum Noise Level of the Editor’s Signal on the Choice of Referee.

is more likely to choose a negatively biased expert referee over a generalist referee. The larger the potential improvement that the editor himself can bring to the refereeing process, the more disciplined will be the negatively biased expert referee, and therefore, he will choose a lower bias probability in equilibrium. Table 6 shows that as the editor’s effort efficiency decreases (i.e., as $\bar{w}$ increases, the
Numerical Results with $R = 500$, $g = 0.62$, $p_1 = 0.70$, $p_2 = 0.80$, $B = 40$, $K = 80$, $r_{min} = 0.23$.

### Table 6: The Effect of the Editor’s Effort Efficiency on the Choice of Referee.

<table>
<thead>
<tr>
<th>$\bar{w}$</th>
<th>Negatively Biased Expert</th>
<th>Generalist</th>
</tr>
</thead>
<tbody>
<tr>
<td>$b$</td>
<td>$r$</td>
<td>$w$</td>
</tr>
<tr>
<td>2.2</td>
<td>0.2886</td>
<td>0.2728</td>
</tr>
<tr>
<td>2.3</td>
<td>0.2904</td>
<td>0.2750</td>
</tr>
<tr>
<td>2.4</td>
<td>0.2920</td>
<td>0.2770</td>
</tr>
<tr>
<td>2.5</td>
<td>0.2934</td>
<td>0.2788</td>
</tr>
<tr>
<td>2.6</td>
<td>0.2947</td>
<td>0.2804</td>
</tr>
<tr>
<td>2.7</td>
<td>0.2959</td>
<td>0.2818</td>
</tr>
</tbody>
</table>

Numerical Results with $g = 0.62$, $p_1 = 0.70$, $p_2 = 0.80$, $B = 40$, $K = 80$, $r_{min} = 0.23$, $\bar{w} = 2.3$.

### Table 7: The Effect of the Payoff to the Journal from Publishing a High Quality Paper on the Choice of Referee.

<table>
<thead>
<tr>
<th>$R$</th>
<th>Negatively Biased Expert</th>
<th>Generalist</th>
</tr>
</thead>
<tbody>
<tr>
<td>$b$</td>
<td>$r$</td>
<td>$w$</td>
</tr>
<tr>
<td>450</td>
<td>0.2916</td>
<td>0.2766</td>
</tr>
<tr>
<td>475</td>
<td>0.2910</td>
<td>0.2758</td>
</tr>
<tr>
<td>500</td>
<td>0.2904</td>
<td>0.2750</td>
</tr>
<tr>
<td>525</td>
<td>0.2898</td>
<td>0.2743</td>
</tr>
<tr>
<td>550</td>
<td>0.2892</td>
<td>0.2735</td>
</tr>
<tr>
<td>575</td>
<td>0.2886</td>
<td>0.2728</td>
</tr>
</tbody>
</table>

Finally, Table 7 shows that as the payoff to the journal from publishing a high quality paper increases ($R$ increases as $L$ and other parameters are kept constant), the editor is more likely to choose a generalist referee over a negatively biased expert referee. If a journal is more concerned about minimizing type I error (i.e., it wants to lower the probability of falsely rejecting good quality papers) rather than avoiding bad quality papers at all costs (minimizing type II error), the editor will prefer unbiased generalist referees over negatively biased experts for a greater range of parameters.
8 Implications

We now discuss the empirical and policy implications of our model.

(i) Optimal choice of referee between experts and generalists: Our analysis demonstrates that choosing a referee in a scientific area closest to that of the paper is not always optimal from the point of view of the journal. This is because the referee who is most knowledgeable in the scientific area related to the paper may also be the one who is most biased (either positively or negatively) toward a particular paper. Thus, our analysis suggests that the choice of referee should be made by trading off the superior knowledge of an expert referee with the greater impartiality of a generalist.

(ii) Accounting for the bias of expert referees: Our analysis suggests that, in situations where it is indeed optimal to use an expert referee due to his superiority in area-specific knowledge over the generalist, the editor should explicitly account for the potential bias of this expert referee, to the extent possible. While, in our model, we assume that an expert referee’s bias is known to the editor, as a practical matter, the above implies that editors should attempt to unearth and keep track of the biases of prominent expert referees. This further implies that policies that explicitly encourage authors of manuscripts to bring the conflicts of interest of potential referees to the editor’s attention (or even to veto some referees) may be optimal.

(iii) The relation between the editor’s prior opinion and the optimal choice of referee in the one referee case: Our analysis suggests that, consistent with practice, an editor who has a very low prior opinion of a paper will desk-reject a paper; an editor with a very high prior opinion of a paper will desk-accept it. Further, it suggests that, if the editor has a low prior opinion of a paper (but this opinion is above the desk-rejection region), he will optimally send it to a negatively biased expert referee. On the other hand, if the editor has a high prior opinion of the paper (but this prior is below the desk-acceptance region) he will optimally send it to a positively-biased expert referee. Finally, if the editor’s prior opinion is in-between the above two regions, he will optimally send it to a generalist (for moderate values of the expert referees’ bias and of the difference in signal precision between generalist and expert referees). The above implications indicate that the often-heard complaint that editors tend to

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45 Note, however, that our model also shows that, even when the editor knows the bias of an expert referee precisely, he cannot completely eliminate the information loss arising from this bias.

46 Consistent with this, some medical and other scientific journals allow authors to veto a specific number of academic scholars as potential referees.
send papers from lesser known authors to referees inclined to recommend rejection does not reflect any personal bias against them on the part of the editor, but simply reflects optimal journal policy corresponding to a low prior opinion on the part of the editor.

(iv) The relation between the characteristics of the journal and the editor’s choice of referees: Our analysis suggest that a journal’s characteristics and their effect on an editor’s objective function will influence his optimal choice of referees. Thus, if a journal is very well established, so that the editor is much more concerned about ensuring that all bad papers are rejected rather than ensuring that all good papers get accepted (i.e., \( L \gg R \) in our setting), then he is more likely to choose a generalist or a negatively biased expert referee rather than a positively biased expert referee (for a given value \( g \) of the editor’s prior belief about the paper). Conversely, if the journal is less well established, so that the editor is much more concerned about ensuring that all good papers are accepted rather than about ensuring that no bad paper is accepted (i.e., \( R \gg L \) in our setting), then he is more likely to choose a generalist or a positively biased expert referee rather than a negatively biased expert referee (for a given value \( g \) of the editor’s prior belief about the paper).47

(v) The choice between one versus two generalist referees: Our analysis suggests that, if the editor can aggregate recommendations from multiple referees efficiently (i.e., using Bayes’ rule), then the editor’s choice between using one generalist referee versus two generalist referees to evaluate a paper depends on the trade-off between the cost involved in hiring an additional referee versus the benefit of doing so, which arises from the additional information provided by this referee. In particular, if the marginal cost of hiring an additional referee is trivially small, it is always optimal to hire an additional generalist referee.

(vi) The relation between the editor’s prior opinion and the optimal choice of referee in the two referees case: Assuming that the cost-benefit trade-off favors the editor using two referees to evaluate a paper, our analysis has several interesting predictions. First, similar to the one referee case, for extreme values of the editor’s prior opinion, he will either desk-reject the paper (very low prior) or desk-accept the paper (very high prior). Second, for moderate values of the expert referees’ bias and of the difference in signal precision between generalist and expert referees, our model predicts the following: For values

\[ b \]

47As we show in Proposition 3(iii), the choice between a generalist and a negatively biased expert (when \( L > R \)) and the choice between a generalist and a positively biased expert (when \( R > L \)) will depend upon the editor’s prior belief about the paper and the bias \( b \) of the expert referee.
of his prior immediately adjacent to the above extremes, he will use two referees of similar bias: two positively biased expert referees if his prior is immediately below the desk-acceptance region, and two negatively biased expert referees if his bias is immediately above the desk-rejection region. For values of his prior in the two regions adjacent to the above mentioned regions (with referees of similar bias), the editor will choose expert referees with opposite biases: in other words, if his prior is above the region where he opts for two negatively biased expert referees or below the region where he opts for two positively biased expert referees, he will optimally choose two expert referees with biases opposite to each other to evaluate the paper. Finally, if his prior is in-between the above two regions where he opts for two expert referees of opposite biases, the editor will choose two generalists to evaluate the paper.

(vii) The choice between one versus two expert referees: Our analysis suggests that, when the editor can aggregate information from multiple referees efficiently (i.e., using Bayes’ Rule), then the editor’s choice between using one versus two versus two expert referees to evaluate a paper depends on the trade-off between the cost involved in hiring an additional referee versus the benefit of doing so (arising from the additional information provided by this referee). In particular, if the cost involved in hiring an additional referee is trivially small and the editor can aggregate information from multiple referees efficiently, it is always optimal for the editor to use two expert referees to evaluate a paper rather than one expert referee. This is because the editor is able to ensure that there is some residual useful information from using the additional expert referee, even though the editor knows that his report is likely to be biased. In practice, many journals may adopt ad hoc rules for aggregating the information from multiple referees (rather than Bayes’ rule), such as requiring both referees to make favorable recommendations before a paper can be accepted by the journal. Our analysis shows that, under such ad hoc rules, it is no longer the case that two expert referees are better than one, even when the marginal cost of using an additional referee is zero: we show that, in such cases, the incremental bias introduced by having a second expert referee to evaluate the paper may overcome the benefit of the incremental information obtained by the editor by using an additional referee. Of course, the choice between one versus two expert referees depends on the extent of the expert referees’ bias: if the referee’s bias is sufficiently small (and the marginal cost of an additional referee is zero) it may be optimal to have two referees instead of one (as common intuition may suggest), even under ad hoc...
information aggregation rules.

(viii) The relation between the characteristics of the editor and the quality of refereeing: Our strategic reporting model has several implications for the relationship between the characteristics of a journal’s editor and the information to bias ratio of the recommendations provided to it by referees. First, our model suggests that, if the editor is more able, so that his own signal regarding a paper is more precise for a given amount of resources he commits to it, then the referee is likely to strategically lower his bias, thus increasing the information to bias ratio of his reports to the editor.\textsuperscript{48} Second, if the editor is able to penalize referees who he assesses have turned in biased reports to a greater extent (keeping other variables such as the precision of the editor’s own signal regarding the paper constant), then the information to bias ratio of the referee’s reports to the editor will be greater. Third, our analysis suggests that, in many cases, it is optimal for the editor to override a referee’s recommendation based on his own signal: i.e., accept a paper in the face of a negative recommendation from a referee or reject a paper in the face of a positive recommendation.

(ix) The optimal structure and consequences of a journal’s dispute resolution procedure: Even though we do not explicitly model a journal’s dispute resolution procedure, the independent signal generated by the journal editor in our strategic reporting model can be viewed as being generated by a dispute referee (rather than being generated by the editor himself). In this formulation, our model has two implications for a journal’s dispute resolution procedure. First, the presence of a dispute resolution procedure not only provides an additional signal to the editor (when the dispute resolution procedure is invoked by a paper’s author), but the possibility of the author invoking this procedure will also increase the informativeness to bias ratio of the first referee’s report (assuming that, as in our strategic reporting model, the editor will impose a penalty on the first referee if the dispute referee disagrees with the first referee). Second, our analysis suggests that the dispute referee should be asked to produce a completely independent signal rather than his signal being influenced by the first referee in some form (for example, by being provided with the first referee’s report), since this will provide the greatest disciplining effect on the first referee, thus increasing the informativeness to bias ratio of his report to the greatest extent.

\textsuperscript{48}As a practical matter, the precision of the editor’s independent signal (for a given amount of resources committed to evaluate the paper) can be increased either by having a more able editor or by having a team of editors, each having expertise in evaluating papers in a given area.
9 Conclusion

We have developed a model of the editorial process in scientific journals and institutions awarding research grants (like the National Science Foundation). In our model, a journal editor has the objective of maximizing his journal’s expected payoff from publishing high quality papers, net of its costs arising from (mistakenly) publishing low quality papers. While the editor has a prior probability assessment regarding the quality of papers that are submitted to his journal, in many cases he can benefit from additional evaluations of these papers performed by (one or more) referees. Potential referees receive noisy signals about a paper’s quality. While some referees (“generalists”) are neutral regarding the paper, other referees (“experts”), who have more precise signals regarding paper quality than generalists, may also have a bias (positive or negative) regarding the paper. Considerations of cost limit the number of referees to a small number. In our basic model, expert referees are endowed with their bias, and cannot change this bias strategically; further, the editor does not have the ability to generate additional signals of his own regarding paper quality or impose any penalties on referees he believes made a biased report to him. The editor’s job in the basic model is therefore to decide whether or not to desk-reject (or accept) a paper based on his prior evaluation of the paper’s quality, whether to send it out for refereeing (and if so, to choose the kind and number of referees to send the paper to), and upon receiving one or more referee reports, to optimally make use of the information in these reports to accept or reject the paper. In our extended (“strategic reporting”) model, we allow the editor to generate his own additional signal regarding a paper’s quality, though the precision of this signal depends on how much of his limited resources (e.g., time) the editor devotes toward evaluating a paper. In this extended model, we also allow each referee to choose how biased a report to send to the editor, knowing that, if the editor suspects a referee of sending a biased report, he has the ability to impose a penalty on her. Our model generates a number of testable predictions and policy implications regarding how to improve the editorial process in scientific journals.
References


Appendix

Proof of Proposition 1:

Desk rejection is relevant if \( g \leq \bar{g} \), and desk acceptance is relevant if \( g > \bar{g} \). Rearranging inequality (13) and isolating \( g \) on the LHS, we obtain the condition that if \( 0 < g \leq k_1 \), the editor desk-rejects the paper. Rearranging inequality (15) and isolating \( g \) on one side of the inequality, we obtain the condition \( s_1 \leq g < 1 \), under which the editor desk-accepts the paper. Note that the restriction in (15) can be further simplified as: \( (1 - g)p_1L - g(1 - p_1)R > c \), before we re-express in its final form in (16).

For the interval \( (k_1, \bar{g}) \) to exist, i.e., \( k_1 < \bar{g} \), the following restriction must hold:

\[
c < (2p_1 - 1)\frac{LR}{L + R}. \tag{A.1}
\]

Otherwise, we will have \( k_1 > \bar{g} \), and desk-rejection will be always optimal if \( g \leq \bar{g} \). For the interval \( (\bar{g}, s_1) \) to exist, i.e., \( s_1 > \bar{g} \), the same restriction on \( p_1 \) and \( c \) in (A.1) as above must hold as well. Otherwise, we will have \( s_1 < \bar{g} \), and desk-acceptance will be always optimal if \( g > \bar{g} \). Thus, the restriction \( c < (2p_1 - 1)\frac{LR}{L + R} \) ensures that \( k_1 < \bar{g} \) and \( s_1 > \bar{g} \). Therefore, it follows that if \( k_1 < g < s_1 \), the editor prefers to send the paper to a generalist referee.

The fixed cost \( c \) of using a referee must be small enough, so that \( c < p_1R \), since, otherwise, desk rejection would always dominate using a generalist referee (because \( k_1 \) would then be greater than 1). Similarly, the restriction \( s_1 > 0 \) requires that \( c < p_1L \). Note that the restriction (A.1) implies that \( c < p_1R \) and \( c < p_1L \).

One should note that the lower threshold value \( k_1 \) is increasing in \( c \) and \( L \), and it is decreasing in \( R \) and \( p_1 \). Note that \( \frac{\partial k_1}{\partial c} = \frac{1}{p_1R + (1 - p_1)L} > 0 \) and \( \frac{\partial k_1}{\partial R} = -\frac{p_1(c + (1 - p_1)L)}{(p_1R + (1 - p_1)L)^2} < 0 \). Note also that \( \frac{\partial k_1}{\partial L} = \frac{(1 - p_1)(p_1R - c)}{(p_1R + (1 - p_1)L)^2} > 0 \) if and only if \( p_1R - c > 0 \), and that \( \frac{\partial k_1}{\partial p_1} = \frac{L(c - p_1R - R(c + (1 - p_1)L))}{(p_1R + (1 - p_1)L)^2} < 0 \) if \( p_1R - c > 0 \).

Finally, one should note that the upper threshold value \( s_1 \) is increasing in \( p_1 \) and \( L \), and it is decreasing in \( c \) and \( R \). Note that \( \frac{\partial s_1}{\partial p_1} = \frac{R(p_1L - c) + L(c + (1 - p_1)L)}{(p_1L + (1 - p_1)L)^2} > 0 \) if \( p_1L - c > 0 \), and \( \frac{\partial s_1}{\partial L} = \frac{p_1(c + (1 - p_1)L)}{(p_1L + (1 - p_1)L)^2} > 0 \) if and only if \( p_1L - c > 0 \), and that \( \frac{\partial s_1}{\partial c} = -\frac{1}{p_1L + (1 - p_1)L} < 0 \).

Proof of Proposition 2:

Desk rejection is relevant if \( g \leq \bar{g} \), and desk acceptance is relevant if \( g > \bar{g} \). Rearranging inequality (27) and isolating \( g \) on the LHS, we obtain the condition that if \( 0 < g \leq k_2 \), the editor desk-rejects the paper. Rearranging inequality (29) and isolating \( g \) on one side of the inequality, we obtain the condition \( s_2 \leq g < 1 \), under which the editor desk-accepts the paper. Note that the restriction in (29) can be further simplified as: \( (1 - g)[1 - (1 - b)(1 - p_2)]L - g[1 - (1 - b)p_2]R > c \), before we re-express in its final form in (30).

For the interval \( (k_2, \bar{g}) \) to exist, i.e., \( k_2 < \bar{g} \), the following restriction must hold:

\[
c < (1 - b)(2p_2 - 1)\frac{LR}{L + R}. \tag{A.2}
\]

Otherwise, we will have \( k_2 > \bar{g} \), and desk-rejection will be always optimal if \( g \leq \bar{g} \). For the interval \( (\bar{g}, s_2) \) to exist, i.e., \( s_2 > \bar{g} \), the same restriction on \( p_2 \), \( b \), and \( c \) in (A.2) as above must hold as well. Otherwise, we will have \( s_2 < \bar{g} \), and desk-acceptance will be always optimal if \( g > \bar{g} \). Thus, the restriction \( c < (1 - b)(2p_2 - 1)\frac{LR}{L + R} \) ensures that \( k_2 < \bar{g} \) and \( s_2 > \bar{g} \). Therefore, it follows that if \( k_2 < g < s_2 \), the editor prefers to send the paper to a negatively biased expert referee.

The fixed cost \( c \) of using a referee must be small enough, so that \( c < (1 - b)p_2R \), since, otherwise, desk rejection would dominate using a negatively biased expert referee (because \( k_2 \) would then be
greater than 1). Similarly, the restriction \( s_2 > 0 \) requires that \( c < |p_2 + b(1 - p_2)|L \). Note that the restriction (A.2) implies that \( c < (1 - b)p_2 R \) and \( c < |p_2 + b(1 - p_2)|L \).

One should note that the lower threshold value \( k_2 \) is increasing in \( c, b, \) and \( L \), and it is decreasing in \( R \) and \( p_2 \). Note that \( \frac{\partial k_2}{\partial c} = \frac{1}{(1 - b)(p_2 R + (1 - p_2)L)} > 0 \), \( \frac{\partial k_2}{\partial b} = \frac{(1 - b)(p_2 R + (1 - p_2)L)^2}{(p_2 R + (1 - p_2)L)^2} > 0 \), and \( \frac{\partial k_2}{\partial R} = -\frac{p_2 (\hat{c}^k + (1 - p_2)L)}{(p_2 R + (1 - p_2)L)^2} < 0 \). Note also that \( \frac{\partial k_2}{\partial L} = \frac{(1 - p_2)(p_2 R - \hat{c}^k)}{(p_2 R + (1 - p_2)L)^2} > 0 \) if and only if \( p_2 R - \frac{c}{1 - b} > 0 \), and that \( \frac{\partial k_2}{\partial p_2} = \frac{L(\hat{c}^k - p_2 R) - R(\hat{c}^k + (1 - p_2)L)}{(p_2 R + (1 - p_2)L)^2} < 0 \) if \( p_2 R - \frac{c}{1 - b} > 0 \).

Finally, one should note that the upper threshold value \( s_2 \) is increasing in \( p_2 \) and \( L \), and it is decreasing in \( c, b, \) and \( R \). Note that \( \frac{\partial s_2}{\partial p_2} = (1 - b)\frac{LR(1 - p_2) + R(2p_2 - 1)b + cL}{(p_2 + b(1 - p_2))L + (1 - p_2)b R + (2p_2 - 1)b R} > 0 \) if \( (p_2 + b(1 - p_2))L - c > 0 \), and \( \frac{\partial s_2}{\partial L} = \frac{\partial s_2}{\partial p_2} = \frac{(p_2 + b(1 - p_2))L + (1 - p_2)b R + c(p_2 + b(1 - p_2))}{(p_2 + b(1 - p_2))L + (1 - p_2)b R + (2p_2 - 1)b R} > 0 \). Note also that \( \frac{\partial s_2}{\partial b} = -\frac{LR(1 - 2p_2) + c(1 - p_2)L + p_2 R}{((p_2 + b(1 - p_2))L + (1 - p_2)b R)^2} < 0 \) if \( c < \frac{(2p_2 - 1)LR}{(1 - p_2)L + p_2 R} \) (which is satisfied if (A.2) holds). Finally, note also that \( \frac{\partial s_2}{\partial R} = -\frac{(p_2 + b(1 - p_2))L - c(p_2 + b(1 - p_2))}{((p_2 + b(1 - p_2))L + (1 - p_2)b R)^2} < 0 \) if \( (p_2 + b(1 - p_2))L - c > 0 \).

**Proof of Proposition 3:** By comparing the editor’s expected payoff from employing a generalist referee and his expected payoff from employing a negatively biased expert referee, we obtain the cutoff prior belief \( g_n \) (defined in (37)) so that the editor prefers the generalist referee to the negatively biased expert referee iff \( g > g_n \). Note that \( g_n \) is decreasing in \( b \) since

\[
\frac{\partial g_n}{\partial b} = \frac{-(p_2 - p_1)LR}{b(p_2 R + (1 - p_2)L) - (p_2 - p_1)(R - L)} < 0. \tag{A.3}
\]

The bias threshold \( b_1 \) is defined by the equality of \( s_1 \) and \( s_2 \) defined earlier in Propositions 1 and 2 respectively \( (s_1 < s_2 \text{ if and only if } b < b_1) \). Moreover, if \( b = b_1 \), we also have \( s_1 = s_2 = g_n \). It is easy to verify that \( k_2 < k_1 < s_1 < s_2 < g_n \) if and only if \( b < b_1 \). Thus, the negatively biased expert referee dominates the generalist referee if \( b < b_1 \). The bias threshold \( b_2 \) is defined by the equality of \( k_1 \) and \( k_2 \) defined earlier in Propositions 1 and 2 respectively \( (k_1 < k_2 \text{ if and only if } b < b_2) \). Moreover, if \( b = b_2 \), we also have \( g_n = k_1 = k_2 \). It is easy to verify that \( k_2 < k_1 < g_n < s_2 < s_1 \) if and only if \( b_1 < b < b_2 \). On the other hand, \( g_n < k_1 < k_2 < s_2 < s_1 \) if and only if \( b > b_2 \). Thus, the generalist referee completely dominates the negatively biased expert referee if \( b > b_2 \). Further, \( g_n \in [k_1, s_1] \) iff \( b_1 \leq b \leq b_2 \).

We next derive some results regarding the editor’s choice between a positively biased expert referee, a generalist referee, and desk rejection or desk acceptance. Consider the case when the editor has only a positively biased expert referee available to him. In that case, desk rejection is relevant if \( g \leq \hat{g} \), and desk acceptance is relevant if \( g > \hat{g} \). If \( g \leq \hat{g} \), the editor will choose to employ a positively biased expert referee for peer review iff

\[
g[(p_2 + (1 - p_2)b)R - (1 - g)(1 - p_2 + p_2b)L - c > 0. \tag{A.4}
\]

Rearranging (A.4) and isolating \( g \) on the LHS, we obtain the condition that if

\[
0 < g \leq k_3 \equiv \frac{c + [(1 - p_2) + p_2b]L}{[(1 - p_2) + p_2b]R + [(1 - p_2) + p_2b]L}, \tag{A.5}
\]

the editor will desk-reject the paper. Otherwise, if \( k_3 < g < \hat{g} \), the editor will optimally choose to send the paper to the positively biased expert referee. On the other hand, if \( g > \hat{g} \), the editor will
choose to employ a positively biased expert referee for peer review iff
\[ g[p_2 + (1 - p_2)b]R - (1 - g)[(1 - p_2) + p_2b]L - c \geq gR - (1 - g)L. \]  
(A.6)

Rearranging (A.6) and isolating \( g \) on the LHS, we obtain the condition that if
\[ s_3 \equiv \frac{(1 - b)p_2 L - c}{(1 - b)p_2 L + (1 - p_2)R} \leq g < 1, \]  
(A.7)

the editor will desk-accept the paper. Otherwise, if \( \bar{g} < g < s_3 \), the editor will optimally choose to send the paper to the positively biased expert referee. The restriction \( \frac{c}{(1-b)(2p_2-1)} < \frac{LR}{L+R} \) ensures that \( k_3 < \bar{g} \) and \( s_3 > \bar{g} \).

We know that if \( g \in [\max\{k_1, k_3\}, \min\{s_1, s_3\}] \), the editor prefers employing either a positively biased expert or a generalist referee to desk rejection or desk acceptance. In that case, he will prefer the positively biased expert referee for any level of his prior belief \( g > g \).

By rearranging (A.8), we solve for the cut-off value \( g_p \) of the prior belief \( g \), at which the editor is indifferent between the generalist referee and the positively biased expert referee:

\[ g_p = \frac{(p_1 - (1 - b)p_2)L}{(p_2 - p_1 + b(1 - p_2))R + (p_1 - (1 - b)p_2)L}. \]  
(A.9)

Thus, the positively biased expert referee will be preferred to the generalist referee iff \( g > g_p \). \( g_p \) is increasing in \( b \), since \( \frac{dg_p}{db} = \frac{(p_2 - p_1)L(R - L)}{(p_2 - p_1)L + c(p_2 L + (1 - p_2)R)} > 0 \).

If the bias of the positively biased expert referee is small enough so that
\[ b < b_3 \equiv \frac{(p_2 - p_1)(LR + c(R - L))}{LR(p_1 + p_2 - 1) - c(p_2 L + (1 - p_2)R)}, \]  
(A.10)

the editor will prefer the positively biased expert to the generalist for any level of his prior belief \( g \) in the range \((k_3, s_3)\). The bias threshold \( b_3 \) is defined by the equality of \( k_1 \) and \( k_3 \) defined earlier in Proposition 1 and in (A.5) respectively \((k_3 < k_1 \iff b < b_3)\). Moreover, if \( b = b_3 \), we also have \( g_p = k_1 = k_3 \). It is easy to verify that \( g_p < s_3 < k_1 < s_1 < s_3 \) if \( b < b_3 \). Thus, the positively biased expert referee dominates the generalist referee if \( b < b_3 \).

Similarly, if the bias of the positively biased expert referee is very large so that
\[ b > b_4 \equiv \frac{(p_2 - p_1)(LR - c(R - L))}{(p_2 - p_1)L R + c(p_2 L + (1 - p_2)R)}, \]  
(A.11)

the editor will prefer the generalist to the positively biased expert for any level of his prior belief \( g \) in the range \((k_1, s_1)\). The bias threshold \( b_4 \) is defined by the equality of \( s_1 \) and \( s_3 \) defined earlier in Proposition 1 and in (A.7) respectively \((s_3 > s_1 \text{ if and only if } b < b_4)\). Moreover, if \( b = b_4 \), we also have \( g_p = s_1 = s_3 \). It is easy to verify that \( k_1 < k_3 < g_p < s_1 < s_3 \) if \( b_3 < b < b_4 \). On the other hand, \( k_1 < k_3 < s_3 < s_1 < g_p \) if \( b > b_4 \). Thus, the generalist referee completely dominates the positively biased expert referee if \( b > b_4 \).

In summary, it follows from the above discussion that if \( b < b_3 \), we have \( g_p < k_3 < k_1 < s_1 < s_3 \). If \( b_3 < b < b_4 \), we will have \( k_1 < k_3 < g_p < s_1 < s_3 \). Finally, if \( b > b_4 \), we have \( k_1 < k_3 < s_3 < s_1 < g_p \). Further, \( g_p \in [k_1, s_1] \) if \( b_3 \leq b \leq b_4 \). Thus, if \( b_3 \leq b \leq b_4 \), the editor’s optimal policy is as follows:
if $0 < g < k_1$, the editor desk-rejects the paper. If $k_1 \leq g \leq g_p$, the editor sends the paper to the generalist referee. If $g_p < g \leq s_3$, the editor sends the paper to the positively biased expert referee. If $s_3 < g < 1$, he desk-accepts the paper.

Now, finally consider the editor’s choice among a generalist referee, a negatively biased expert referee, a positively biased expert referee, and desk rejection or acceptance. The quantity $\tilde{b}$ is defined by the equality of either $g_p$ or $g_n$ to $\tilde{g}$, and it is equal to $\frac{2(p_2-p_1)}{2p_2-1}$. If $b < \tilde{b}$, we have $g_p < \tilde{g}$ and $g_n > \tilde{g}$. Earlier, we showed that $g_p$ is increasing in $b$, and $g_n$ is decreasing in $b$. In the case where $g_p < \tilde{g} < g_n$, if the editor’s prior belief $g$ is less than the threshold $\tilde{g}$, he prefers the negatively biased expert referee to the generalist since $g < \tilde{g} < g_n$; however, if $g > \tilde{g}$, he prefers the positively biased expert referee to the generalist since $g_p < \tilde{g} < g$. From (47), we also know that the editor prefers the positively biased expert referee to the negatively biased one if $g > \tilde{g}$. Thus, the first part of Proposition 3 follows.

If $b \geq \tilde{b}$, we have $g_n \leq \tilde{g} \leq g_p$. In this case, it follows from the above discussion that the editor’s optimal choice is to send the paper to a generalist referee if $g_n \leq g \leq g_p$. We also know that the generalist referee will not dominate the negatively biased expert referee and the positively biased referee as long as $b < b_2$ and $b < b_4$, respectively. Recall that $b_2$ is defined by the equality $g_n = k_1 = k_2$ whereas $b_4$ is defined by the equality $g_p = s_1 = s_3$. If $b > b_2$, we have $g_n < k_1 < k_2$. Similarly, if $b > b_4$, we have $s_3 < s_1 < g_p$. Thus, the second and third parts of Proposition 3 follow. Whether $b_4 > b_2$ or $b_2 > b_4$ depends on the relationship between $R$ and $L$. Given the definitions of $b_2$ and $b_4$ in equations (41) and (45) respectively, $b_4 > b_2$ iff the following condition holds:

$$\frac{(2p_1-1)RL}{R+L} > 1.$$  \hspace{1cm} (A.12)

By our assumption on $c$, we know that $\frac{(2p_1-1)RL}{R+L} > 1$. Thus, it follows that $b_4 > b_2$ if and only if $R > L$. Thus, if $R > L$, part (iii)(a) of the proposition holds. Otherwise, if $R < L$, part(iii)(b) of the proposition holds. Further, in the special case where $R = L$, it holds that $b_2 = b_4$ and part (iii) collapses into part (ii). Finally, if $b > \max\{b_2, b_4\}$, the generalist referee totally dominates both types of biased expert referees as shown above. ■

**Proof of Proposition 4:** We compare the editor’s expected payoff from employing two generalist referees to that from employing only one referee. The editor’s expected payoff from sending the paper to two generalist referees is as follows:

$$gp_1^2 R - (1-g)(1-p_1)^2 L + 2p_1(1-p_1) \max\{0, gR - (1-g)L\} - 2c.$$  \hspace{1cm} (A.13)

If $g > \tilde{g} = \frac{L}{L+R}$, then this expected payoff will be equal to

$$gp_1(2-p_1)R - (1-g)(1-p_1^2)L - 2c.$$  \hspace{1cm} (A.14)

Otherwise, if $g \leq \tilde{g} = \frac{L}{L+R}$, then the editor’s expected payoff will be equal to

$$gp_1^2 R - (1-g)(1-p_1)^2 L - 2c.$$  \hspace{1cm} (A.15)

On the other hand, we know that editor’s expected payoff from employing only one generalist referee is given by

$$gp_1 R - (1-g)(1-p_1)L - c.$$  \hspace{1cm} (A.16)
If \( g > \bar{g} \), the difference between (A.14) and (A.16) is equal to
\[
p_1(1 - p_1)[gR - (1 - g)L] - c.
\] (A.17)

If \( g \leq \bar{g} \), the difference between (A.15) and (A.16) is equal to
\[
p_1(1 - p_1)\{(1 - g)L - gR\} - c.
\] (A.18)

These two conditions can be equivalently expressed as restrictions on \( c \) as in (57) and (56), respectively.

**Proof of Proposition 5:** The proof of part (i) follows from the comparison of the editor’s expected payoff from employing two generalist referees to those from sending the paper to two negatively biased expert referees and two positively biased expert referees. The threshold bias \( b_{21} \) given in (72) is defined by either one of these two equalities: \( g_{nn}^{\text{low}} = \bar{g}_n = g_{nn}^{\text{mid}} \) and \( g_{pp}^{\text{mid}} = \bar{g}_p = g_{pp}^{\text{up}} \), where \( g_{nn} \) and \( g_{pp} \) were defined in (61) and (68), respectively. The other parameters are defined as follows:

\[
g_{nn}^{\text{low}} = \frac{L[(1 - p_1)^2 - (1 - b)^2(1 - p_2)^2]}{L[(1 - p_1)^2 - (1 - b)^2(1 - p_2)^2] + R[p_1^2 - (1 - b)^2p_2^2]},
\] (A.19)

\[
g_{nn}^{\text{mid}} = \frac{L[(1 - b)(1 - p_2)(1 + b + (1 - b)p_2) - (1 - p_1)^2]}{L[(1 - b)(1 - p_2)(1 + b + (1 - b)p_2) - (1 - p_1)^2] + R[(1 - b)p_2(2 - (1 - b)p_2) - p_1^2]},
\] (A.20)

\[
g_{pp}^{\text{mid}} = \frac{L[(1 - p_1^2) - (1 - p_2 + bp_2)^2]}{L[(1 - p_1^2) - (1 - p_2 + bp_2)^2] + R[p_1(2 - p_1) - (p_2 + b(1 - p_2))^2]},
\] (A.21)

\[
g_{pp}^{\text{up}} = \frac{L[(1 - p_2)^2 + b(2 - b)p_2^2 + 2p_2(1 - p_2) - (1 - p_1^2)]}{L[(1 - p_2)^2 + b(2 - b)p_2^2 + 2p_2(1 - p_2) - (1 - p_1^2)] + RT},
\] (A.22)

where \( T = [p_2^2 + b(2 - b)(1 - p_2)^2 + 2p_2(1 - p_2) - p_1(2 - p_1)] \). Without loss of generality, if we set \( g_{nn}^{\text{low}} \) equal to \( \bar{g}_{nn} \), we obtain a quadratic equation in \( b \), and its solution is equal to \( b_{21} \) given in (72). From the definition of these parameters, it follows that, if \( b \leq b_{21} \), two negatively biased expert referees will dominate two generalist referees for prior beliefs where \( g \leq \bar{g} \). Similarly, if \( b \leq b_{21} \), two positively biased expert referees will dominate two generalist referees for prior beliefs where \( g > \bar{g} \).

The proof of part (iii) also follows from the comparison of the editor’s expected payoff from employing two generalist referees to those from sending the paper to two negatively biased expert referees and two positively biased expert referees. If the bias probability \( b \) is so large so that \( g_{nn}^{\text{mid}} = \bar{g} = g_{nn}^{\text{up}} \) and \( g_{pp}^{\text{low}} = \bar{g} = g_{pp}^{\text{mid}} \), two generalist referees will dominate both two negatively biased expert referees and two positively biased expert referees. Thus, by equating \( g_{pp}^{\text{low}} \), which is defined as
\[
g_{pp}^{\text{low}} = \frac{L[(1 - p_2 + bp_2)^2 - (1 - p_1)^2]}{L[(1 - p_2 + bp_2)^2 - (1 - p_1)^2] + R[(p_2 + b(1 - p_2))^2 - p_1^2]},
\] (A.23)

or \( g_{nn}^{\text{up}} \), which is defined as
\[
g_{nn}^{\text{up}} = \frac{L[(1 - p_1^2) - (1 - b)(1 - p_2)(1 + b + (1 - b)p_2)]}{L[(1 - p_1^2) - (1 - b)(1 - p_2)(1 + b + (1 - b)p_2)] + R[p_1(2 - p_1) - (1 - b)p_2(2 - (1 - b)p_2)]},
\] (A.24)

to \( \bar{g} = \frac{L}{L + R} \), we obtain a quadratic equation in \( b \), for which the solution is equal to \( \sqrt{\frac{2p_2-p_1}{2p_2-1}} \).

In part (ii) of the proposition, the threshold bias \( b_{31} \) is defined by the following equality: \( k_{gg} = k_{nn} = g_{nn}^{\text{low}} \) (or equivalently, by \( s_{pp} = g_{pp}^{\text{up}} = s_{gg} \)). Without loss of generality, if we set \( k_{gg} = k_{nn} \) and
solve for \( b \) that satisfies this equation, we obtain

\[
b_{31} = 1 - \sqrt{\frac{2c[(1 - p_1)^2L + p_1^2R]}{LR[(1 - p_1)^2p_2^2 - (1 - p_2)^2p_1^2] + 2c[(1 - p_1)^2L + p_1^2R]}}. \quad (A.25)
\]

The parameters \( g_{np}^{low} \) and \( g_{nn}^{up} \) were defined earlier in \((A.23)\) and \((A.24)\), respectively. If \( b_{21} < b < b_{31} \), the following order relationship holds: \( k_{nn} < g_{nn}^{low} < g_{pp}^{low} < g_{nn}^{up} < g_{pp}^{up} < s_{pp} \). This leads to the decision rule given in part (ii).

**Proof of Proposition 6:** We only present the proof for the case of two negatively biased expert referees versus one positively biased expert referee since the proof for the case with positive bias is symmetric.

First, let \( g \leq \tilde{g}_{nn} = \frac{(1 - p_2)(p_2 + b(1 - p_2))L}{(1 - p_3)(p_3 + b(1 - p_3))L + p_2(1 - p_2 + bp_2)R} \). Then, the editor will prefer two negatively biased expert referees to a single positively biased expert referee iff the following condition holds:

\[
(1 - b)^2(gp_2^2R - (1 - g)(1 - p_2)^2L) - 2c \geq (1 - b)(gp_2R - (1 - g)(1 - p_2)L) - c. \quad (A.26)
\]

Rearranging this inequality and isolating \( c \) on the LHS, we obtain

\[
c \leq (1 - b)[(1 - g)(1 - p_2)(p_2 + b(1 - p_2))L - gp_2(1 - p_2 + bp_2)R]. \quad (A.27)
\]

This condition is satisfied strictly as an inequality if \( g < \tilde{g}_{nn} \), and it holds as an equality only if \( g = \tilde{g}_{nn} \). Second, let \( g > \tilde{g}_{nn} \). In this case, the editor will strictly prefer two negatively biased expert referees to a single negatively biased expert referee iff the following condition holds:

\[
(1 - b)^2(gp_2^2R - (1 - g)(1 - p_2)^2L) + 2(1 - b)[gp_2(1 - p_2 + bp_2)R - (1 - g)(1 - p_2)(p_2 + b(1 - p_2))L] - 2c > (1 - b)(gp_2R - (1 - g)(1 - p_2)L) - c, \quad (A.28)
\]

Rearranging this inequality and isolating \( c \) on the LHS, we obtain

\[
c < (1 - b)[gp_2(1 - p_2 + bp_2)R - (1 - g)(1 - p_2)(p_2 + b(1 - p_2))L]. \quad (A.29)
\]

Thus, from \((A.27)\) and \((A.29)\), it follows that

\[
c_n(g) = (1 - b) \left| gp_2(1 - p_2 + bp_2)R - (1 - g)(1 - p_2)(p_2 + b(1 - p_2))L \right|. \quad (A.30)
\]

In the case of two positively biased expert referees versus one positively biased expert referee, we similarly obtain the threshold

\[
c_p(g) = (1 - b) \left| g(p_2 + b(1 - p_2))(1 - p_2)R - (1 - g)(1 - p_2 + bp_2)p_2L \right|. \quad (A.31)
\]

**Proof of Proposition 7:** The proof follows from the comparison of the editor’s expected payoff from employing two generalist referees to that from sending the paper to two oppositely biased expert referees.

First, the threshold bias \( \bar{b} = \frac{2(p_2 - p_1)}{2p_2 - 1} \) is defined by the following equality: \( g_{np}^{low} = \bar{g} = g_{np}^{up} \). The parameter \( g_{np}^{low} \) is the threshold above which the editor prefers two generalist referees to two oppositely biased expert referees when \( g < \bar{g} \). Similarly, \( g_{np}^{up} \) is the threshold under which the editor prefers two generalist referees to two oppositely biased expert referees when \( g \geq \bar{g} \). However, when \( b = 0 \) initially, we have \( g_{np}^{up} < \bar{g} < g_{np}^{low} \). Thus, two oppositely expert referees dominate two generalists for any prior
belief \( g \). This will continue to hold until \( g_{np}^{low} = \bar{g} = g_{np}^{up} \). Note that \( g_{np}^{up} \) is increasing in \( b \), and \( g_{np}^{low} \) is decreasing in \( b \). The parameter \( g_{np}^{low} \) is defined as follows:

\[
g_{np}^{low} = \frac{[(1 - p_1)^2 - (1 - b)(1 - p_2)(1 - p_2 + bp_2)]L}{[(1 - p_1)^2 - (1 - b)(1 - p_2)(1 - p_2 + bp_2)]L + [p_1^2 - (1 - b)p_2(p_2 + b(1 - p_2))]R}. \tag{A.32}
\]

When we set \( g_{np}^{low} \) equal to \( \bar{g} = \frac{L}{L + R} \), we obtain a quadratic equation in \( b \), the solution for which is equal to \( \bar{b} = \frac{2(p_2 - p_1)}{2p_2 - 1} \).

Second, when the bias probability \( b \) is so large that \( g_{np}^{up} = s_{gg} \) (or equivalently, \( g_{np}^{low} = k_{gg} \)), two oppositely biased experts will be dominated by two generalists for any prior \( g \). The parameter \( g_{np}^{up} \) is defined as follows:

\[
g_{np}^{up} = \frac{L[(1 - p_2)^2 + bp_2^2 + (2 - b + b^2)p_2(1 - p_2) - (1 - p_1^2)]}{L[(1 - p_2)^2 + bp_2^2 + (2 - b + b^2)p_2(1 - p_2) - (1 - p_1^2)] + RU}, \tag{A.33}
\]

where \( U \equiv [p_2^2 + b(1 - p_2)^2 + (2 - b + b^2)p_2(1 - p_2) - p_1(2 - p_1)] \). If we set \( g_{np}^{up} \) equal to \( s_{gg} = \frac{p_1^2L - 2c}{p_1^2L + (1 - p_1)^2R} \), we obtain a quadratic equation in \( b \), the solution for which is equal to \( b_{np} \) given in (82).

Lastly, if \( \bar{b} < b < b_{np} \), it holds that \( g_{np}^{low} < \bar{g} < g_{np}^{up} \). From the definition of these parameters, it holds that, in this case, the editor will prefer two generalist referees to two oppositely biased expert referees if and only if \( g_{np}^{low} < g < g_{np}^{up} \).

**Proof of Proposition 8:** The restriction \( b < \bar{b} = \frac{2(p_2 - p_1)}{2p_2 - 1} \) is imposed for analytical simplicity in order to focus on cases where two oppositely biased expert referees still dominate two generalist referees and thus, the comparison is between two oppositely biased experts and pairs of expert referees with the same bias. The proof follows from the comparison of the editor’s expected payoff from employing two oppositely biased expert referees to those of employing two negatively biased expert referees and two positively biased expert referees, respectively. Note that \( \bar{g}_{nn} < \bar{g} < \bar{g}_{np} \). The parameter \( g_{np,nn,1} \) is defined as the threshold prior belief, under which the editor prefers two negatively biased expert referees to two oppositely biased expert referees when \( g < \bar{g}_{nn} \):

\[
g_{np,nn,1} = \frac{L(1 - p_2)}{L(1 - p_2) + Rp_2}. \tag{A.34}
\]

Thus, if \( k_{nn} < g \leq g_{np,nn,1} \), the editor prefers two negatively biased expert referees to two oppositely biased expert referees. Further, if \( g > g_{np,nn,1} \), there exists a prior belief interval \( [g_{np,nn,1}, g_{np,nn,2}] \), in which the editor prefers two oppositely biased expert referees to two negatively biased expert referees. The parameter \( g_{np,nn,2} \) is defined as the threshold prior belief, above which the editor prefers two negatively biased expert referees to two oppositely biased expert referees when \( \bar{g}_{nn} \leq g \leq \bar{g} \):

\[
g_{np,nn,2} = \frac{L(1 - p_2)(2p_2 - b(2p_2 - 1))}{L(1 - p_2)(2p_2 - b(2p_2 - 1)) + Rp_2(2(1 - p_2) - b(2(1 - p_2) - 1))}. \tag{A.35}
\]

Further, if \( g \in [g_{np,nn,1}, g_{np,pp,1}] \), the editor will prefer two oppositely biased experts to two positively biased expert referees as well, since \( g_{np,pp,1} \) is defined as the threshold prior belief, below which the editor prefers two oppositely biased expert referees to two positively biased expert referees when \( g \leq \bar{g} \):

\[
g_{np,pp,1} = \frac{L(1 - p_2 + bp_2)}{L(1 - p_2 + bp_2) + Rp_2(2(1 - p_2) - b(2(1 - p_2) - 1))}. \tag{A.36}
\]
It is straightforward to verify that \( g_{np,pp,1} < g_{np,nn,2} \). Thus, the editor prefers two oppositely biased expert referees to expert referee pairs with the same bias if \( g \in [g_{np,nn,1}; g_{np,pp,1}] \). Further, since \( g_{np,nn,1} < g_{nn,pp,1} \) (\( g_{nn,pp,1} \) is the threshold prior below which the editor prefers two negatively biased expert referees to two positively biased expert referees when \( g \leq \bar{g}_{nn} \)), it follows that for \( k_{nn} < g \leq g_{np,nn,1} \), the editor also prefers two negatively biased expert referees to two positively biased expert referees.

Similarly, the parameter \( g_{np,pp,3} \) is defined as the threshold prior belief, above which the editor prefers two positively biased expert referees to two oppositely biased expert referees when \( g > \bar{g}_{pp} \):

\[
g_{np,pp,3} = \frac{Lp_2}{Lp_2 + R(1 - p_2)}. \tag{A.37}
\]

Thus, if \( g_{np,pp,3} \leq g < s_{pp} \), the editor prefers two positively biased expert referees to two oppositely biased expert referees. Further, if \( g < g_{np,pp,3} \), there exists a prior belief interval \( [g_{np,pp,2}; g_{np,pp,3}] \), in which the editor prefers two oppositely biased expert referees to two positively biased expert referees. The parameter \( g_{np,pp,2} \) is defined as the threshold prior belief, below which the editor prefers two positively biased expert referees to two oppositely biased expert referees when \( \bar{g} < g \leq \bar{g}_{pp} \):

\[
g_{np,pp,2} = \frac{L(b(1 - b)p_2^3 + (2 - 3b + b^2)p_2(1 - p_2))}{L(b(1 - b)p_2^3 + (2 - 3b + b^2)p_2(1 - p_2)) + R(b(1 - b)(1 - p_2)^2 + (2 - 3b + b^2)p_2(1 - p_2))}. \tag{A.38}
\]

Further, if \( g \in [g_{np,nn,3}; g_{np,pp,3}] \), the editor will prefer two oppositely biased experts to two negatively biased expert referees as well, since \( g_{np,nn,3} \) is defined as the threshold prior belief, above which the editor prefers two oppositely biased expert referees to two negatively biased expert referees when \( g > \bar{g} \):

\[
g_{np,nn,3} = \frac{L(p_2^3 + b(1 - p_2) + p_2(1 - p_2))}{L(p_2^3 + b(1 - p_2) + p_2(1 - p_2)) + R((1 - p_2)^2 + bp_2 + p_2(1 - p_2))}. \tag{A.39}
\]

It is straightforward to verify that \( g_{np,nn,3} > g_{np,pp,2} \). Thus, the editor prefers two oppositely biased expert referees to expert referee pairs with the same bias if \( g \in [g_{np,nn,3}; g_{np,pp,3}] \). Further, since \( g_{np,pp,3} > g_{nn,pp,3} \) (\( g_{nn,pp,3} \) is the threshold prior above which the editor prefers two positively biased expert referees to two negatively biased expert referees when \( g > \bar{g}_{pp} \)), it follows that for \( g_{np,pp,3} \leq g < s_{pp} \), the editor also prefers two positively biased expert referees to two negatively biased expert referees.

**Proof of Proposition 9:** Under the given ad hoc rule, the editor will prefer a single negatively biased expert referee to two negatively biased expert referees if and only if the following condition holds:

\[
(1 - b)(gp_2R - (1 - g)(1 - p_2)L) - c > (1 - b)^2(gp_2^2R - (1 - g)(1 - p_2)^2L) - c, \tag{A.40}
\]

which is equivalent to

\[
g > \frac{(1 - p_2)(p_2 + b(1 - p_2))L}{(1 - p_2)(p_2 + b(1 - p_2))L + p_2(1 - p_2 + bp_2)R} = \bar{g}_{nn}. \tag{A.41}
\]

Similarly, under the given ad hoc rule, the editor will prefer a single positively biased expert referee to two positively biased expert referees if and only if the following condition holds:

\[
g[p_2 + b(1 - p_2)]R - (1 - g)[1 - p_2 + bp_2]L - c > g[p_2 + b(1 - p_2)]^2R - (1 - g)[1 - p_2 + bp_2]^2L - c, \tag{A.42}
\]

Thus, the editor prefers two positively biased expert referees to two negatively biased expert referees if and only if the following condition holds:
which is equivalent to
\[ g > \frac{p_2(1 - p_2 + b p_2) L}{p_2(1 - p_2 + b p_2) L + (1 - p_2)(p_2 + b(1 - p_2)) R} = \tilde{g}_{pp}. \tag{A.43} \]

It is straightforward to verify that \( \tilde{g}_{nn} < \tilde{g} < \tilde{g}_{pp}, \frac{\partial \tilde{g}_{nn}}{\partial b} < 0, \) and \( \frac{\partial \tilde{g}_{pp}}{\partial b} > 0. \)

**Proof of Proposition 10:** The best response functions of the referee and the editor given in equations (88) and (91), respectively, comprise a system of two equations in two variables (\(r\) and \(b\)). Isolating \(b\) on the LHS of each equation, we obtain the following equation in \(r\):
\[ \frac{a_7 - r}{b_7} = \frac{a_8 - a_9(1 - r)^2 - a_{10}r(1 - r)}{a_{11}(1 - r)^2 + a_{12}r(1 - r)} \tag{A.44} \]
where the parameters of this equation are defined as follows:
\[
\begin{align*}
 a_7 &\equiv (1 - p_1) - \frac{a_2^2}{2W_0} (g(1 - p_2) R + (1 - g)p_2 L), \\
b_7 &\equiv \frac{a_2^2}{2W_0} (gp_2 R + (1 - g)(1 - p_2)L), \\
a_8 &\equiv (gp_2 + (1 - g)(1 - p_2))B, \\
a_9 &\equiv g(1 - p_2)K, \\
a_{10} &\equiv (1 - g)p_2K, \\
a_{11} &\equiv 2gp_2K, \\
a_{12} &\equiv 2(1 - g)(1 - p_2)K.
\end{align*} \tag{A.45} \]

Rearranging equation (A.44) yields the cubic equation (94). After transposing this equation into a canonical \(Ar^3 + Br^2 + Cr + D = 0\) form, if the discriminant of this cubic equation is negative, its unique real root is given by
\[
 r^* = -\frac{B}{3A} - \frac{1}{3A} \sqrt{\frac{1}{2} \left[ 2B^3 - 9ABC + 27A^2D + \sqrt{(2B^3 - 9ABC + 27A^2D)^2 - 4(B^2 - 3AC)^3} \right] - \frac{1}{3A} \sqrt{\frac{1}{2} \left[ 2B^3 - 9ABC + 27A^2D - \sqrt{(2B^3 - 9ABC + 27A^2D)^2 - 4(B^2 - 3AC)^3} \right]}. \tag{A.46} \]

Substituting \(r^*\) in equations (88) and (85), we obtain the equilibrium values of \(a\) and \(b^*\) and \(w^*\), respectively.

**Proof of Proposition 11:** Without loss of generality, we give the proof in the case of strategic reporting with a negatively biased expert referee. The proof is symmetric in the case of a positively biased expert referee. From the equilibrium equation (A.44) of the strategic reporting game,
\[
 F = \frac{a_8 - a_9(1 - r)^2 - a_{10}r(1 - r)}{a_{11}(1 - r)^2 + a_{12}r(1 - r)} + \frac{r - a_7}{b_7} = 0. \tag{A.47} \]

From the implicit differentiation theorem, it follows that
\[ \frac{dr}{da} = -\frac{\frac{\partial F}{\partial r}}{\frac{\partial F}{\partial a}}. \tag{A.48} \]

Note that \(\frac{\partial F}{\partial r} > 0\) since the best response function of the referee given in (90) is increasing in \(r\). More
precisely,
\[
\frac{\partial F}{\partial r} = \frac{(2a_9(1 - r) + (2r - 1)a_{10})(a_{11}(1 - r)^2 + a_{12}r(1 - r))}{(a_{11}(1 - r)^2 + a_{12}r(1 - r))^2}
- \frac{(a_8 - a_9(1 - r)^2 - a_{10}r(1 - r))(-2a_{11}(1 - r) + (1 - 2r)a_{12})}{(a_{11}(1 - r)^2 + a_{12}r(1 - r))^2} + \frac{1}{b_7} > 0. \tag{A.49}
\]

Solving for the numerator of (A.48), we obtain
\[
\frac{\partial F}{\partial a} = \frac{s^3}{2W_a^2} \left[ (g(1 - p_2)R + (1 - g)p_2L)(gp_2R + (1 - g)(1 - p_2)L) + (gp_2R + (1 - g)(1 - p_2)L)^2 \right] b_7^2 > 0. \tag{A.50}
\]
Thus, it follows that \( \frac{dx}{da} < 0 \). Then, from the chain rule and the referee’s best response function in (88), it follows that \( \frac{db}{da} < 0 \). Note that since the parameters \( B \) and \( K \) have no direct effect on the editor’s best response function in (91), it follows from the referee’s best response function in (88) that \( \frac{db}{dB} > 0 \) and \( \frac{db}{dK} < 0 \). \( \square \)