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Single versus multiple submissions in the publication process

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ABSTRACT

In this dissertation, we develop a model to investigate some implications of single and multiple submissions policies of academic journals. We make the following four assumptions. First, authors are identical and they produce papers with the same quality distribution; Second, there are only two journals and their quality standards are common knowledge; Third, the errors in the referee's assessment of papers' quality are uncorrelated. Finally, if a paper is rejected by a journal it can not be resubmitted to the same journal in the future. We find that if multiple submissions were allowed, the average quality of accepted papers could be higher or lower than those in the single submission case. Therefore, a multiple-submission policy may not necessarily deteriorate the quality of published papers. In addition, we find that, as authors become less patient they are more likely to choose multiple submissions, and if authors are sufficiently patient they never choose multiple submissions. Thus, authors who are not very patient suffer more from the prevailing policy of prohibiting multiple submissions. We also found that under the situation that authors are patient enough, whether multiple-submission may occur in their optimal submission strategy depends on the magnitude of publication benefit in the high quality journal. When the publication benefit in the high quality journal is small enough, authors will never include multiple-submission in their optimal strategy.

CHAPTER 1. OVERVIEW

1.1 Introduction

Recent studies indicate that there has been a trend of increasing length in publication process in many disciplines over the last several decades. The increasing publication delay in academic journals has caused criticism by scholars because publications are the primary route for them to get promotion, tenure, salary increase and recognition. Many scholars tried to understand the cause of the slowdown in the publication process. Azar (2003) divided the delay in publication process into four stages and argued that previous studies about the delay have ignored the rejection-and-revision stage (the time between the submission of a manuscript to the first journal and its submission to the journal that eventually publishes it). After accounting for this stage, the first response time (FRT, the time between submission and first decision in the journal in which the manuscript is eventually published) will have a much more important impact on the publication delay because it may delay the process more than once since manuscripts are often rejected from more than one journal before being accepted. Azar (2002) provided evidence that the FRT of economics journals has increased from about 1-2 months to 4-5 months over the last four decades.

Most of the scholarly journals prohibit multiple submissions.[1] There is a debate concerning the desirability of allowing multiple submissions. Szenberg (1994) argued that allowing multiple submissions can speed up the decision time involved in getting papers accepted for publication because it would make the editorial process more competitive and it would also lead to quicker acceptances through elimination of "rejection waiting time" (having to wait for one rejection before being able to send a paper to another journal). Pressman (1994) argued that multiple submissions would not substantially reduce the response time on individual papers, and it may

[1] The law discipline is an exception. Law journals do permit multiple submissions. (Posner, 2004)

increase the number of submissions of low-quality papers to top journals, thus increasing the workload of referees and editors without any significant benefit in terms of the quality of research published. Although there is an intense debate, there are very few formal models on this issue so far. In this paper, we develop a model to investigate some implications of single and multiple submissions policies of academic journals. We make the following four assumptions. First, authors are identical and know their papers' true quality perfectly; Second, there are only two journals and their quality standards are common knowledge; Third, the errors in the referees' assessment of papers' quality are uncorrelated. Finally, if a paper is rejected by a journal, it can not be resubmitted to the same journal in the future.

From the analysis on authors' submission strategy, we find in a multi-period setting, that given the ratio of publication benefit to submission fee in the low quality journal, if authors' are patient enough they will never submit their papers to both journals simultaneously. Otherwise, whether multiple-submission may occur in their optimal submission strategy depends on the magnitude of the publication benefit in the high quality journal. When the publication benefit in the high quality journal is small enough, authors will never include multiple-submission as part of their optimal strategy. When the publication benefit in the high quality journal is relatively large, a multiple-submission strategy may be optimal.

Through numerical simulations, we find that if multiple submissions were allowed, the average quality of accepted papers could be higher or lower than those in the single submission case. Therefore, a multiple-submission policy may not necessarily deteriorate the quality of published papers. We also find that, as authors become less patient, they are more likely to choose multiple submissions, and if authors are sufficiently patient they never choose multiple submissions. Thus, authors who are not very patient suffer more from the prevailing policy of prohibiting multiple

submissions. From the simulation results, we also find that a less (more) patient author is more likely to submit his paper to the low (high) quality journal.

1.2 Organization of the dissertation

The dissertation is organized as follows. Chapter 2 is a literature review on the publication process. Chapter 3 presents the modeling setup and investigates the submission strategy in the basic model. Chapter 4 performs numerical simulations on an author's submission strategy in the single and multiple-submission cases. Chapter 5 makes the concluding remarks.

CHAPTER 2. LITERATURE REVIEW

This chapter introduces the literature on the publication process. First, we organize the literature about a delayed publication process and present the empirical and theoretical analysis results by some scholars. Second, we introduce the literature about the peer review system. Third, we present the literature about citations as measurement of papers' quality. Fourth, we introduce the arguments on a "single-submission" or "multiple-submission" policy. We conclude by summarizing some suggestions for further research, and introduce the motivation for our model.

2.1 The delayed publication process

The publishing process plays an important role in both the dissemination and certification of scientific knowledge. Recent studies indicate that there has been a trend of delayed publishing process in many disciplines over the last few decades. In particular, Ellison (2002a) found that over the last 30 years there has been a substantial slowdown of the publishing process in the economics discipline (see table 1) and figure 1 shows the mean submit-accept times for papers published at top economics journals. Based on a database which concerns the author's own 66 published papers in 28 different journals for the period of 1990-1999, Franses (2002a) constructed a group of descriptive statistics, such as submission-first response time, revision-decision time and decision-publication time, then provided some model-based regression results which reinforces one of the findings in Ellison (2002a) that the publishing process now takes longer.

Table 1: Mean submit-accept times at various journals

Journal	Mean total review time in year			
	1970	1980	1990	1999
Top five general interest journals				
American Economic Review		a13.5	12.7	
Econometrics	b8.8	b14.0	b22.9	b26.3
Journal of Political Economy		9.5	13.3	20.3
Quarterly Journal of Economics	8.1	12.7	22.0	13.0
Review of Economic Studies	b10.9	21.5	21.2	28.8
Other general interest journals				
Canadial Journal of Economics		a11.3		16.6
Economic Inquiry		a3.4		13.0
Economic Journal		a9.5		b18.2
International Economic Review	b7.8	b11.9	b15.9	b16.8
Review of Economics and Statistics	8.1	11.4	13.1	18.8
Economic field journals				
Journal of Applied Econometrics			b16.3	b21.5
Journal of Comparative Economics		b10.3	b10.9	b10.1
Journal of Development Economics	bc5.6	b6.4	b12.6	b17.3
Journal of Econometrics		b9.7	b17.6	b25.5
Journal of Economic Theory	b0.6	b6.1	b17.0	b16.4
Journal of Environmental Ec. & Man.		b5.5	b6.6	b13.1
Journal of International Economics		a8.7		16.2
Journal of Law and Economics		a6.6		14.8
Journal of Mathematical Economics	bc2.2	b7.5	17.5	8.5
Journal of Monetary Economics			b11.7	b16.0
Journal of Public Economics	bc2.6	b12.5	b14.2	b9.9
Journal of Urban Economics		b5.4	b10.3	b8.8
RAND Journal of Economics		a7.2	20.0	20.9
Journals in related fields				
Accounting Review		10.1	20.7	14.5
Journal of Accounting and Economics		b11.4	b12.5	b11.5
Journal of Finance		a6.5		18.6
Journal of Financial Economics	bc2.6	b7.5	b12.4	b14.8

Note: The table is from Ellison (2002a) and records the mean time between initial submission and acceptance for articles published in various journals in various years.

(a) Data from Yohe (1980) is for 1979 and probably does not include the review time for the final resubmission.
(b) Does not include review time for final resubmission.
(c) Data for 1974. d - Data for 1972.

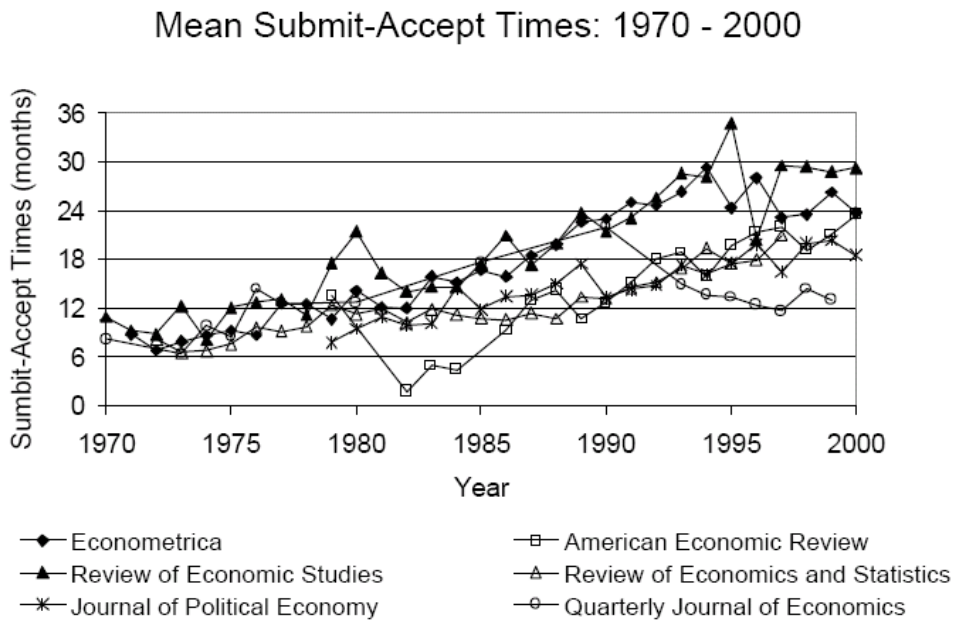

Figure 1: Mean submit-accept times for papers in top general interest journals

Note: The figure is from Ellison (2002a)

There are many theoretical and empirical studies on the issue of publication process. Franses (2002a) mentioned that there are mainly two types of studies. The first type considers how the papers proceeded through the editorial process and the second type is concerned with what happens to the papers once they have been published. As is illustrated in Franses (2002b), very successful papers in economics and econometrics can get around 150 citations per year for a period of a decade. The author stated that there are very few studies that follow the full life cycle of individual papers over time. In his article, Franses conducted an empirical analysis to study the full life cycle of papers, ranging from submission to citations. The analysis was based on a database which concerns the author's own 66 published papers in 28 different journals for the

period of 1990-1999. According to the information contained in the database, the author provides two types of descriptive statistics: one concerns the published papers, such as standardized citations, whether the paper appeared in a special issue or not, the number of pages, the number of references, the number of prior rejections and so on; the other type is concerned with the editorial process, such as submission-first response time, revision-decision time and decision-publication time. The author provided some model-based regression results and an important conclusion which reinforces the findings in Ellison (2002a) that the editorial process now takes longer and that only a few papers get frequently cited.

The delayed publishing process has received a lot of criticism because it makes the dissemination of knowledge slower and it may cause the entire chain of research to be delayed since new research builds on previous works. Many scholars tried to figure out the reason of the slowdown in the publishing process. Ellison (2002a) provided some potential explanations for the delayed publishing process in economics. He attributed part of the slowdown to a few changes in the economics profession. By using time-series data, he examined whether the change has actually occurred and by using cross-section data he examined the hypothesized relationship between the change and the slowdown. He analyzed four exogenous changes in the profession.

The first change is the “democratization” of the publishing process and this may lengthen the review time of papers. But time-series data on the characteristics of accepted papers showed there has not been significant democratization over the past three decades and cross-section data doesn’t support this hypothesis either. The second change is an increase in the complexity of economics papers. Some tests support this complexity-based explanation but others do not. The third change is the growth in the economics profession and this might slow the review process at top journals through two effects: it may increase the workload of editors and it may increase competition for the limited space in journals. According to the results of the regression, the author

concluded that the first effect was hard to support and the second effect may account for three or four months of the slowdown at the top journals. The fourth change is in the costs and benefits of revising papers. One argument is that the improvements in computer technology reduced the cost of revisions and journals may ask for more revisions. The other argument is that more revisions are optimal because journals may be less in the business of disseminating information and more in the business of certifying the quality of papers. But these explanations can not be supported by evidence.

Ellison (2002a) concluded that it is hard to attribute the majority of the slowdown to observable changes in the economics profession and he tried to provide an alternative hypothesis: the slowdown could reflect a shift in social norms. Ellison (2002b) developed a model in which social norms would evolve in the direction of emphasizing revisions and hence a delayed publishing process, given the assumption that academics are subject to overconfidence bias (they think their work is slightly better than what it really is). In this article, the author developed a two-dimensional quality model to explain the trends in academic publishing process: academic journals require extensive revisions of submissions and articles are becoming longer.

Firstly, the author formulated a simple static model of academic publishing. The main actors in this model are a continuum of academics (of unit mass). Each of them is endowed with one unit of time and may write one paper. Papers have a two-dimensional quality, q and r. The q-dimension reflects the contribution of the main idea of the paper and the r-dimension reflects other aspects of quality, such as robustness checks, extensions, and discussions of related literature. There is one journal which publishes a mass τ of papers with $0 < \tau < 1$. Academics' preferences are lexicographic in publications and leisure, which implies they attempt to maximize the probability of publishing an article in the journal. The social norm (α, z) for evaluating papers

is common knowledge. Papers are regarded as worthy of publication if and only if $\alpha q + (1-\alpha)r \geq z$. The model is described as a four-step process with three groups of players. In the first stage, academics choose the fraction $t_q \in [0,1]$ of their time to devote to developing the main idea of the paper. In the second stage, academics submit their papers to the journal. The journal's referees correctly assess the q-quality of the paper and report that it will be acceptable for publication if and only if it can be revised to achieve an r-quality of at least $r(q)$ as defined by $\alpha q + (1-\alpha)r(q) = z$. In the third stage, academics choose the amount of time $t_r \in [0,1-t_q]$ to spend on revisions. In the fourth stage, editors accept the fraction τ of papers for which $\alpha q + (1-\alpha)r$ is highest for publication. An equilibrium of the static model is a quadruple $(\alpha, z, t_q^*, t_r^*(q))$ such that t_q^* and $t_r^*(q)$ are chosen to maximize the probability that $\alpha q + (1-\alpha)r \geq z$ and the fraction of papers with $\alpha q + (1-\alpha)r \geq z$ is exactly τ. And (α, z) in this equilibrium is called a consistent social norm. Analysis of the equilibrium may provide a few explanations for an increase in r-quality hence the trends in academic publishing (trends in academic publishing mentioned above can be thought of as reflecting an increase in the r-quality of published papers).

For this static model, a continuum of social norms is possible. Differences in social norms provide a potential explanation for differences in the publishing process across fields or over time. In order to investigate whether social norms might tend to shift, the author developed a dynamic model to examine the evolution of social norms that is consistent with observed trends. The most important actors in the dynamic model are the journal's referees who can learn the prevailing social norm from two sources: seeing what revisions they are asked to make on their own papers and whether editors accept or reject papers they refereed. With the assumption that academics have no overconfidence bias ($\varepsilon = 0$), the author analyzed the basic version of this dynamic model

and concluded that it cannot explain the long gradual trends. By adding the assumption that academics are subject to overconfidence bias (they think their work is slightly better than it really is), the result is a gradual evolution of social norms to higher weight on r-quality. This dynamics is slow and steady and may be a candidate for explaining observed trends in academic publishing.

Azar (2003) divided the delay in publishing process into four stages:

1) "Rejection-and-revision time": the time between the submission of a manuscript to the first journal and its submission to the journal that eventually publishes it.
2) "First response time in the publishing journal": the time between submission and first decision in the journal in which the manuscript is eventually published.
3) "Revision time": the time between the first editorial decision and the acceptance of the article.
4) "Forthcoming-article delay": the time between acceptance of the article and its actual publication in print.

Azar (2003) argued that previous studies about the delay caused by the review process ignored the rejection-and-revision time and looked on the life cycle of an article starting at the point at which it was submitted to the journal that eventually published it. After accounting for the rejection-and-revision stage, the first response time (FRT) will have a much more important impact on the publication delay because it delays the process more than once as manuscripts are often rejected from one or more journals before being accepted for publication. Using empirical evidence about acceptance rates of journals with different rankings, the author estimated the average number of journals to which a manuscript is submitted before being published. The results indicate that given the possible submission strategies, a manuscript with an average quality level is likely to be submitted to three to six different journals before it is accepted for publication. The author said that this result has an important policy implication for journal editors: the

reduction in the FRT is much more important than the reduction in any other stages of the publication delay. In addition, the estimated number of submissions also gives an idea about the costs of the refereeing process per article published.

Azar (2007) provided evidence that the first response time (the time from submission of a manuscript to first editorial decision; FRT) of economics journals has increased from about 1-2 months to 4-5 months over the last forty years. Realizing the fact that it only takes referees several hours to referee a paper, the author wondered why referees leave papers in the pile for a much longer time today than in the past and he suggested two reasons: one is that the optimal FRT for the society is longer today; the other is that the social norm of how much time it should take to referee a paper has increased. The author argued that the cost of delaying a paper's publication is smaller than in the past because articles can also be available in working paper series or on the website prior to publication, hence the cost of a longer FRT has decreased. Also, he argued that a longer FRT creates a benefit because it can reduce the cost of the refereeing process by reducing the number of submissions of low-quality papers to good journals. Then the author formulated a model to illustrate that these changes in the costs and benefits of a longer FRT lead to an increase in the optimal FRT.

Azar (2007) argued that refereeing time can be thought of as a social norm because referees care about how long it takes their colleagues to review a paper. Taking into account the various preferences of referees including their desire to conform to the social norm and the extent to which they care about the profession's welfare (the optimal FRT), he presented a model to examine the evolution of the social norm of refereeing time and how the refereeing time reacts to changes in the optimal FRT. The results showed that the social norm about how much time it should take to referee a paper has increased and even if many referees do not care about the optimal FRT, almost every referee increases his or her refereeing time following an increase in

the optimal FRT. However, the analysis of the evolution of the social norm in Azar (2007) differs from that in Ellison (2002b). Azar (2007) included the social norm into the structure of referees' preferences and assumed that referees know the level of social norms in each period. In Azar's model, the fact that referees care about the welfare of the profession and the longer optimal FRT for the society have driven the social norm of refereeing time to increase over time. In Ellison (2002b), referees review papers according to the profession's standard or the social norm, but they don't know the exact level of social norms in each period and try to infer it from personal experiences (whether editors accept or reject the papers they refereed). Assuming that academics are subject to overconfidence bias when judging the quality of their own work, such attempts to learn the prevailing norm lead to a shift in social norms.

The delay caused by the review process makes the dissemination of research slower and it may cause the entire chain of research to be delayed because new research builds on previous work. The first response time is an important part of the delay. Editors of many economics journals try to reduce the FRT in their journals and most people believe that it is welfare improving. But Azar (2005) questioned this common belief. By analyzing the structure of costs and benefits in the academic profession, he argued that reducing the FRT may increase the number of submissions of low-quality papers to top journals, thus increasing the workload of referees and editors without any significant benefit in terms of the quality of research published.

Then he formulated a model about how the optimal submission strategy is determined to illustrate his argument. In his model, for a certain manuscript, there is a finite set of journals that may publish it and these journals are ranked according to their quality. The author found that given the submission fee and FRT of level-1 journals (top journals), there is a cutoff probability π, if an author estimates his acceptance chances are higher than π, it is optimal for him to submit his paper to level-1 journals, otherwise he is better off submitting the paper to a low-ranked journal.

According to the model, shortening the FRT reduces the cutoff probability, hence induces more submissions of low-quality papers to top journals. Hence, since shortening the FRT might not be beneficial, the author says that from a social point of view a longer FRT might even be better than the current FRT.

In order to overcome the problem of excessive submissions and gain from reducing the FRT, Azar (2006) suggests the following four ideas that might achieve this goal： increasing submission fees, requiring authors to review papers in proportion to the number of papers they submit, using differential delays conditional on the paper's quality, and banning papers from being submitted after a certain number of rejections. After discussing the advantages and disadvantages of these ideas, Azar (2006) proposed a few ideas for further research, e.g., how much time should referees invest in suggesting improvements to a paper they recommend to reject? (There is a trade-off between giving the author as much helpful feedback as possible and saving the referee's time).

2.2 The peer review system

The role of the publishing process in certifying the quality of scientific knowledge is mainly through the peer review system. Referees of journals are often paid nothing or much less than their time cost for their review work. Engers and Gans (1998) formulated a model to explain why referees are willing to perform their task without payment and why editors and publishers do not find it worthwhile to pay referees to improve their performance. In this model, they assume that referees are concerned about the quality of academic journals and their impact upon this. It was

also assumed that the higher the level of participation of referees, the greater is the journal's quality as better articles are attracted by the quick reviewing process.

They examined a referee's decision to participate in the reviewing process. The model predicted that under quite general conditions, although monetary incentives could play a role in improving the journal quality by eliciting a greater review rate, the increase in journal quality reduces the need for referees to incur private costs to enhance the quality, hence greater payments are required to maintain the higher participation rate. They showed that using monetary incentives to motivate referees, while resulting in an improvement in journal quality, is so costly that it makes such incentives unprofitable, thus editors optimally set referee's payment to zero. In this paper, they also demonstrate that a concern for the journal quality causes both editors and referees to fail to fully internalize the effects of their choices on others. Therefore, even though a positive payment would result in a socially beneficial improvement of journal quality, the equilibrium payment to referees by editors is zero. They suggested that an appropriate subsidy to referees by a third party could enhance the welfare.

Several studies examine the effectiveness of the peer review system in quality control. The study by Rowland (2002) indicated that there are many problems involved in this system, such as subjectivity, bias, abuse, fraud and misconduct. Scholars have made a few suggestions for improvement, like "open peer review" suggested by Williamson (2002) and a web-based reviewing system suggested by Weller (2001). Armstrong (1997) tried to review all published empirical literature concerning journal peer review. He examined how the "quality control" and "fairness to authors" work and found that the current system of peer review which aimed at assuring quality and fairness may discourage innovative findings. Then he suggested the following changes in journal peer review to encourage the publication of papers with innovative findings:

- Invited papers
- Early acceptance procedures
- Simultaneous submissions
- Pre-submission reviews
- Nomination of reviewers by authors
- Results-blind reviews
- Structured review forms
- Open peer review
- Alternate formats

In particular, Armstrong (1997) mentioned that electronic publishing by journals can help to solve the problem of scarce resources and it may replace traditional paper journals as a primary channel for innovative findings. To encourage the publication of innovative findings, he also provided some suggestions for editors, reviewers and authors. He emphasized that the basic principle behind the screening procedure should be changed from whether to publish a paper to how to publish it and the effects on quality and fairness should also be assessed at the same time.

Blank (1991) investigated the impact of single-blind versus double-blind reviewing using data from a unique randomized experiment conducted from May 1987 through the end of May 1989 at The American Economic Review (AER). In this experiment, approximately one-half of the submitted papers were assigned to double-blind reviewing and the other papers were assigned to single-blind reviewing. The data provided information on the gender and institutional rank of both author and referee, the acceptance rates and referee ratings of papers, and how many authors

of double-blind papers can actually be identified by the referee. The primary conclusions are as follows:

1) There are significant differences in acceptance rates and referee ratings between single-blind and double-blind papers. Double-blind papers have lower acceptance rates and lower referee evaluations.

2) There are differences in the acceptance rates across institutional categories between single-blind and double-blind papers. Authors at the top-ranked and low-ranked institutions are little affected, but authors at near-top-ranked institutions have lower acceptance rates under double-blind reviewing.

3) Female authors do slightly better under double-blind reviewing in terms of acceptance rates and referee ratings, but the effects are small and statistically insignificant.

4) Female referees tend to give lower ratings to non-blind papers and tend to give higher ratings to blind papers, while male referees show the opposite pattern.

5) "Truly blind" papers (those papers assigned to double-blind reviewing that cannot be identified by referees) are a selected group of the blind papers (the authors of truly blind papers are usually from low-ranked institutions and have little experience and fame in the profession). By using an instrumental-variable procedure to control for all factors other than true anonymity, the effect of being in the truly blind group on the acceptance rates is smaller and less significant

Laband (1990) suggests that the peer review process functions not only as a screening mechanism to separate low quality papers from high quality ones, but it assists authors in the production of publishable papers, which implies that editors, referees and authors are complementary inputs in the production of published scientific knowledge. Laband (1990) estimated a knowledge production function, one element of which is the editor/referee input. Based on information provided by authors of papers published in several of the top economics journals during 1976-1980, he constructed a number of alternative measures of the editor/referee input, such as comments provided by reviewers and editors. Using subsequent citations of published papers as the measure of quality of knowledge, he examined the relationship between editor/referee input and the citations of published papers. The results indicated that reviewers' comments demonstrate a positive impact on subsequent citations of published papers, while editors' comments show no such impact. This implies that value-adding by editors derives basically from efficient matching of manuscripts and reviewers.

Do editors work efficiently? There are many studies on the behavior of editors. Journal editors who publish papers authored by colleagues and former graduate students are often charged with practicing favoritism. Gerrity and Mckenzie (1978) and Laband (1985) offered evidence to the effect that a large fraction of articles published in The Journal of Political Economy (JPE) were authored by scholars with ties to the University of Chicago. The papers treated with favoritism are usually deemed as of lower quality than those written by scholars with no ties to the editor. Laband and Piette (1994a) tried to examine the relationship between quality of papers and an author's personal ties to the editor.

The authors compiled data on 1,051 full articles published in 28 top economics journals in 1984 to examine the relationship between quality of papers and an author's personal ties to the editor. They investigated the extent to which an author's personal ties to the editor of a journal

influenced subsequent citations to published articles, controlling for author, article, and journal-specific characteristics that might influence citations. The empirical results show that although journal editors occasionally publish substandard papers authored by colleagues and former graduate students, their use of professional connections enables them to find high-impact papers for publication. The evidence indicates that the beneficial impact dominates any harm derived from favoritism, so the use of professional connections by editors enables them to find high-impact papers for publication, which implies that "favoritism" may enhance efficiency in the market for scientific knowledge.

2.3 Citations as measurement of papers' quality

The peer review system plays an important role in certifying the quality of scientific knowledge and the standard of measuring the quality or impact of published knowledge is primarily based on their subsequent citations. Franses (2002b) illustrated that very successful papers in economics and econometrics can get about 150 citations per year for a period of a decade. There is a debate on the use of citations as the measurement of the impact of published articles, the rankings of journals, departments and individual researchers. But so far, the citation method is still widely used in academics and has been set as a standard measuring rod in evaluating and rewarding effort.

There are a lot of papers on citation analysis. Based on the procedure used by Bush, Hamelman and Staaf (1974), Liebowitz and Palmer (1984) constructed an impact-adjusted citation index to calculate the ranking of economics journals. According to the information provided by the Social Science Citation Index (SSCI), they first ranked the journals by the total number of citations received from other journals in 1980. This ranking reflected a journal's accumulated impact on

current authors because the cited articles may have been published at any time during the life of the journal. Journals of recent birth had a much smaller inventory of articles to be cited and in this ranking procedure will be at a disadvantage relative to longer-lived journals. For this reason, they used the citations to articles published in the 1975-1979 period to measure the recent impact of journals. Considering that a journal's impact on highly influential journals was more valuable than its impact on less influential journals, the authors provided a procedure to calculate the ranking of journals by using the impact-adjusted citations. In order to investigate which journals are likely to provide the greatest impact for any given manuscript, they also created two rankings by controlling for the size of journals: one was based on citations per character and the other was based on citations per article. This impact-adjusted citation method analyzed in L-P has many followers and is widely used in the ranking of journals.

Amir (2002) investigated the properties of different ranking methods and made a critical assessment of various impact-adjusted measures, in particular the one proposed by L-P (1984). Palacios-Huerta and Volij (2004) introduced an axiomatic method to the problem of how to rank journals on the basis of their mutual citations. By comparing different ranking methods according to the properties they satisfy and fail to satisfy, they concluded that the invariant method (which was first proposed by Pinski and Narin (1976)) is the only one that can satisfy simultaneously the list of four proposed properties simultaneously. They also claimed that the invariant ranking method based on citations is not the only correct way of measuring impact or quality, and citation analysis, however sophisticated it may be, cannot be a substitute for critical reading and expert judgment.

Laband and Tollison (2003) have shown that in spite of the growth between 1974 and 1996 of resources invested in academic economic research, the percentage of un-cited papers remained constant at about 26 percent (in the five years subsequent to their publication). Van Dalen and

Henkens (2004) mentioned that one outstanding feature of scientific publication and citation behavior is the skewness: most articles receive few or no citations and a few receive numerous citations. They argued that the extreme skewed distribution of citations is that many publications that go unnoticed for a considerable number of years may suddenly attract a lot of attention (so-called 'sleeping beauties'). Furthermore, Van Dalen and Klamer (2005) did some calculations and showed that on a global scale the scientific publication industry costs the world only 0.0006 percent of global income and argued that the information based on citation statistics cannot prove that science is a wasteful competition, actually waste is part of science and competition.

Some social science departments and business schools place extreme emphasis on publications in prestigious journals. Articles in high-status journals usually receive more citations than articles in low-status journals. Starbuck (2005) asked how much more these articles contribute to knowledge and he said that it makes no sense to judge articles solely on the journals in which they are published. In this article, the author used data about the review process to frame a statistical analysis of differences between the top 20%, the middle 40% and the bottom 40% of journals in four fields: economics, psychology, sociology and management.

The analysis indicates that although higher-status journals publish more high-value articles, editorial selection involves considerable randomness. High-status journals publish a few low value articles, low-status journals publish some excellent articles and some of the articles which belong in the highest-value 20% may receive successive rejections from several journals. Starbuck (2005) concluded that for most departments and schools, extreme emphasis on publication in top journals has a significant probability of introducing randomness because the confidence intervals of the true value of articles associated with such publications are very wide. Because articles published in high-status journals receive more citations and hence exert more

influence on scientific value, such a focus on high-status journals may impede the development of knowledge when less-valuable articles receive the endorsement of high visibility.

Realizing that there is a remarkable difference between the prices that commercial publishers charge to libraries for economics journals and the prices charged by professional societies and university presses, Bergstrom (2001) assembled a database which contains the information on pages, prices, costs and citations for 297 English-language economics journals to examine the price differences and conduct a cost-effectiveness analysis. According to their owners, these journals are categorized into three groups: nonprofit publishers, Blackwell publishers (they are intermediate between nonprofit and commercial publishers) and commercial publishers. By analyzing the related data, the author concluded that while the nonprofit publishers are supplying most of the information used by economists, the commercial publishers consume more than 80 percent of the library's budget but supply only one third of all citations.

Bergstrom (2001) mentioned that given that nonprofit and commercial journals use essentially the same technology for journal publication, the large difference in prices is not likely to be explained by differences in costs. To understand how a few commercial publishers could extract huge profits from the academic community despite the possibility of new entrants into the industry and competition from nonprofit journals, the author introduced the notion of a coordination game and showed that in such a game, the presence of potential competitors doesn't necessarily prevent monopoly pricing. In order to prevent the academic community from being stuck in an equilibrium where it will continue to pay huge rents to commercial publishers, the author recommended the following strategies that might help convert the publishing activities to a new equilibrium which will better serve the academic community: expanding nonprofit journals, supporting new electronic journals and punishing overpriced journals.

Laband and Piette (1994b) investigate the changing industrial organization of the economics journal market over the period 1970-1990. Using the methodology employed by Liebowitz and Palmer (1984), they collected data on citations from1970 to 1990 for selected economics journals indexed by both the *Index of Economics Article*s *(IEA)* and the *Social Science Citation Index (SSCI)*. They reported journals' rankings in 1970, 1980, 1990 by unadjusted and impact-adjusted citations per article, and by unadjusted and impact-adjusted citations per typed character space. The results indicated that there was a steady decline in concentration of citations among the top economics journals over this period, which was due to existing journals and new entrants taking market share away from these long-established journals. Nonetheless, there was still an obvious inequality in the distribution of citations in economics journals and this inequality was more pronounced with respect to impact-adjusted citations than unadjusted citations. There had been a decline in the influence of most of the "second-tier" general-interest journals, which resulted from the increased influence of a number of field journals. The rapid entry and success of these field journals reflects the advantages of specialization because it is more cost-effective for scholars to browse through field journals which focus on topics they are interested in. The results also showed an increased impact of economics journals focused on mathematics and statistics and a decreased impact of economic history journals over the period 1970-1990.

2.4 The prevailing single submission policy

As review time and publication delay has increased in traditional journals, the circulation of pre-print papers on the internet has played a major role in the communication of new scientific knowledge. It seems that the role of the traditional journal has gradually been changed from the dissemination to the certification of scientific knowledge. If this is true, then the slowdown in the publishing process may be a good thing for the society because the cost of delaying a paper's

publication has decreased since articles are often available on the internet prior to publication. Many scholars argue that it needs to establish a system to certify the quality of the large number of electronic articles. Riyanto and Yetkiner (2002) proposed a market-based mechanism to act as the screening device for electronic articles. This proposed mechanism is set up in an internet based scientific network and works by matching the demand for and supply of reviews in the network through a non-pecuniary incentive scheme. Whether it is necessary to establish a certification system for electronic articles and how to build the system are the research topics of many academicians.

Publication in scholarly journals is the primary route to promotion, tenure, salary increases and recognition. The slowdown in the publication process has caused a lot of criticism by academicians because it affects their welfare severely. Most of the scholarly journals except the law journals (Posner, 2004) prohibit multiple submissions. Szenberg (1994) argued that allowing multiple submissions can speed up the decision time involved in getting papers accepted for publication. He said that multiple submissions would reduce the time it takes to get a paper accepted for publication in two ways. First, it would make the editorial process more competitive and the journals have an incentive to do a quick refereeing job since they don't want to lose the paper to their competitors. Second, it would also lead to quicker acceptances through elimination of "rejection waiting time" (having to wait for one rejection before being able to send a paper to another journal).

Pressman (1994) argued that there are three main problems with the case for multiple submissions. First, a policy of multiple submissions would not substantially reduce the response time on individual papers and in fact, would likely increase it. Second, regardless of whether acceptances come more quickly or more slowly, a policy of multiple submissions would have negative consequences for the entire economics profession. Finally, even if the policy succeeded in

reducing response time, it would not help individual economists because it cannot increase the number of articles published in refereed journals since journals publish a fixed number of articles in one period. There are also many other arguments against multiple submissions, e.g., 1) it is a waste of time and money through duplication of effort on the part of referees and editorial staff; 2) it will induce low quality papers to be submitted to high quality journals and reduce the quality of published papers; 3) it will cause unnecessary complication of copyright privileges should a manuscript be accepted by two or more journals.

2.5 Motivation of the model

Besides research on the delayed publication process, there are also many investigations on the peer review system, the editor's behavior and citations as a method of measuring papers' quality, etc. There may be some relations between the current peer review system, the editor's behavior and the delayed publication process. What kind of preference does the editor of the journal have? Will the editor choose papers according to the social norm or his own preference? These could be the directions for future research. The increasing publication delay in academic journals has caused a lot of criticism by academicians because publications are the primary route for them to get promotion, tenure, salary increase and recognition. The prevailing "single-submission" policy is blamed by some researchers as one of the causes of the slowdown. Although there is a debate on whether multiple submissions should be allowed, there are not formal models on this issue so far.

In this dissertation, we develop a model to investigate an author's submission strategy under two

different policy regimes: the single submission policy and the multiple-submission policy. Regarding the timely publication, some authors are less patient than others. E.g., assistant professors who are facing tenure decisions value timely publications more than those professors who already have tenure. We will discuss how an author's optimal submission strategy changes as they become more or less patient. After deriving an author's optimal submission strategy, we compare the per-period expected number of submissions and the average quality of published papers in the high and low quality journals under the two different policy regimes.

CHAPTER 3. SUBMISSION STRATEGY

3.1 Submission strategy in one period horizon

There are N identical authors. Each author produces one paper per period with a random quality $q \sim F(q)$ and $q \in (-\infty, \infty)$, where $f(q)$ is the probability density function of q and the production cost is zero. The realization of papers' qualities are private information of their authors and they are uncorrelated. There are two journals which choose to publish the submitted papers. One journal is of "high quality" and the other one is of "low quality". They are labeled with H and L respectively. An author gets a benefit B_H if his paper is published in journal H and gets B_L if it is published in journal L. Here, we assume that $B_H > B_L > 0$. If the paper is published in neither journal, he gets zero. Editors of the two journals hire referees to review submitted papers and each paper is reviewed by one referee. After reviewing a paper, the referee will make an assessment of the paper's quality. But this assessment is noisy, with the value $s = q + \alpha$, where $\alpha \sim G(\alpha)$ with mean zero and $g(\alpha)$ is the $p.d.f$ .The editor of journal j sets a quality standard s_j for his journal, where $j = H, L$ and $s_H > s_L > 0$. This implies that a submitted paper will not be accepted for publication if the quality assessment by the referee is below the standard set by the submitted journal. The two journals' editors charge a fee P_H or P_L for each submission, where $B_H > P_H > 0$, $B_L > P_L > 0$ and $P_H \geq P_L$.

3.1.1 Single submission

In this section, we assume that there is only one period and the authors can submit their papers to only one journal. If a paper is rejected by the journal, the life ends for the paper. Given the editor's choice of s_j, author i decides whether and where to submit his paper after knowing

the paper's quality q_i, where $j = H, L$ and $i = 1, 2, ..., N$. If he submits the paper to journal j, the probability of being accepted for publication is as follows:

(1) $\pi_j(q_i) = \Pr ob(q_i + \alpha_j > s_j) = \Pr ob(\alpha_j > s_j - q_i)$

where α_j represents the random error in the quality assessment of author i's paper by the referee of journal j. Because $\alpha_j \sim G(\alpha)$, (1) is equivalent to

(2) $\pi_j(q_i) = 1 - G(s_j - q_i)$

Therefore, if author i submits his paper to journal j, he gets an expected payoff

(3) $M_j(q_i) = B_j \pi_j(q_i) - P_j$, and $j = H, L$

(4) $M_j'(q_i) = B_j g(s_j - q_i) > 0$

For an author who has a paper with quality q, if $M_H(q) > Max[M_L(q), 0]$, he will submit his paper to the high quality journal; if $M_L(q) > Max[M_H(q), 0]$, he will submit the paper to the low quality journal. In Chapter 3, we will investigate and discuss authors' optimal submission strategies in the following four cases:

1) Single submission and single period case
2) Multiple-submission and single period case
3) Single submission and multiple-period case
4) Multiple-submission and multiple-period case

To investigate an author's submission strategy, we need the following assumptions.

Assumption 1: $B_H > B_L > P_H \geq P_L$

Assumption 2: $\pi_j(q) \in (0,1)$ for all $q \in (-\infty, \infty)$; $\lim_{q \to -\infty} \pi_j(q) = 0$, $\lim_{q \to \infty} \pi_j(q) = 1$, $j = L, H$

Assumption 3: The density function of referee's assessment error g is log-concave.

Define $h(x) \equiv \frac{g(x)}{1-G(x)}$, which is the failure rate or hazard function of distribution G. Bagnoli and Bergstrom (2005) proved that if the density function is log-concave on (a,b), the hazard function is monotone increasing on (a,b). We assume that the density function g is log-concave on $(-\infty,+\infty)$,[2] then the hazard function is upward sloping or $h'(x) > 0$. This implies that the distribution has positive duration dependence. Thus, for a paper with the quality difference level x ($x = (s_j - q)$, which is the difference between a journal's quality standard and the paper's quality), the likelihood of failure (being rejected) at x, conditional upon duration (survival or being accepted) up to x, is increasing in x . In other words, given a journal's quality standard, as the paper's quality rises or the quality difference x declines, the likelihood of being rejected for this paper will decrease.

Lemma 1: There exists a unique q_j *s.t.* $M_j(q_j) = 0$ **,** $j = H, L$

Proof:

Since $M_j(q) = B_j \pi_j(q) - P_j$, with Assumption 1 and 2 we know that $\lim_{q \to -\infty} M_j(q) = -P_j < 0$ and $\lim_{q \to \infty} M_j(q) = B_j - P_j > 0$. Because $M_j(q)$ is continuous and $M_j'(q) = B_j g(s_j - q) > 0$, there must exist a unique $\hat{q}_L$ and q_0**,** *s.t.* $M_L(\hat{q}_L) = 0$ and $M_H(q_0) = 0$

(Q.E.D)

[2] Some commonly-used distributions with log-concave density functions on $(-\infty,+\infty)$ are: normal distribution, logistic distribution, extreme value distribution, double exponential distribution, etc.

Lemma 2: $\exists B_H^u\left(B_L, s_L, s_H, P_H, P_L\right)$ **s.t.** $M_H\left(\hat{q}_L, B_H\right)\begin{matrix}>\\=\\<\end{matrix}0$ **as** $B_H\begin{matrix}>\\=\\<\end{matrix}B_H^u$

Proof:

Define $J\left(B_H\right)=M_H\left(\hat{q}_L\right)=\pi_H\left(\hat{q}_L\right)B_H-p_H$ where $M_L\left(\hat{q}_L\right)=0$

Then $J(0)=-P_H<0$ and $\lim_{B_H\to\infty}J\left(B_H\right)>0$. Since $J\left(B_H\right)$ is continuous and

$J'\left(B_H\right)=\pi_H\left(\hat{q}_L\right)>0$, there must exist a unique B_H^u s.t. $J\left(B_H^u\right)=0$ or $M_H\left(\hat{q}_L, B_H^u\right)=0$.

Since $J'\left(B_H\right)>0$, as $B_H>B_H^u$, we have $M_H\left(\hat{q}_L, B_H\right)>M_H\left(\hat{q}_L, B_H^u\right)=0$; as $B_H<B_H^u$, we

have $M_H\left(\hat{q}_L, B_H\right)<M_H\left(\hat{q}_L, B_H^u\right)=0$

(Q.E.D)

Assumption 4: $B_H\in\left(\left(B_L+P_H-P_L\right), B_H^u\right]$

Define $q_0\left(B_H\right)$ s.t. $M_H\left(q_0, B_H\right)=0$ (from Lemma 1, we know that such a q_0 exists for

each B_H); Define $\hat{q}_H\left(B_H\right)$ s.t. $M_H\left(\hat{q}_H, B_H\right)=M_L\left(\hat{q}_H\right)$

Lemma 3: For $B_H\in\left(\left(B_L+P_H-P_L\right), B_H^u\right]$, we have

1) $q_0\geq\hat{q}_L$ where $M_H\left(q_0\right)=0, M_L\left(\hat{q}_L\right)=0$

2) $\hat{q}_H\to\infty$ as $B_H\to\left(B_L+P_H-P_L\right)^+$

Proof:

According to Lemma 2, we know $M_H\left(\hat{q}_L, B_H^u\right)=0$. Since for each B_H there exists a unique $q_0\left(B_H\right)$ s.t. $M_H\left(q_0, B_H\right)=0$. Then by definition we know $q_0\left(B_H^u\right)=\hat{q}_L$. From $M_H\left(q_0, B_H\right)=0$ and implicit function theorem, we know that

$$\left(dq_0/dB_H\right)=-\frac{\partial M_H/\partial B_H}{\partial M_H/\partial q_0}=-\frac{\pi_H}{B_H g_H}<0.$$

Thus when $B_H \le B_H^u$, we have $q_0\left(B_H\right)\ge q_0\left(B_H^u\right)=\hat{q}_L$.

Let $B_H=\left(B_L+P_H-P_L\right)+\varepsilon;\quad \varepsilon\ge 0$. Then

$M_H-M_L=\pi_H\varepsilon-\left\{\left(\pi_L-\pi_H\right)B_L+\left(P_H-P_L\right)\left(1-\pi_H\right)\right\}$. Since $\pi_L>\pi_H$ for finite q and $P_H\ge P_L$, (M_H-M_L) will be negative as $\varepsilon\to 0^+$ unless $\pi_H\to 1$ which implies $\pi_L\to 1$ and $\hat{q}_H\to\infty$, thus $\hat{q}_H\to\infty$ as $B_H\to\left(B_L+P_H-P_L\right)^+$.

(Q.E.D)

In "single submission and single period" case, an authors' optimal submission strategy can be summarized in the following proposition 1.

Proposition 1:

Given the journals' quality standards s_H and s_L, when Assumptions 1-4 are satisfied, there exist two quality thresholds $\hat{q}_H$ and $\hat{q}_L$ such that an author has the following submission strategy.

1) If the paper's quality satisfies $q\in(-\infty,\hat{q}_L)$, there is no submission.
2) If the paper's quality satisfies $q\in[\hat{q}_L,\hat{q}_H)$, it will be submitted to journal L.
3) If the paper's quality satisfies $q\in[\hat{q}_H,+\infty)$, it will be submitted to journal H.

Where $M_L(\hat{q}_L)=0$ and $M_H(\hat{q}_H)=M_L(\hat{q}_H)$

Proof:

We define a function $D(q)\equiv M_H(q)-M_L(q)$, which is the difference of the expected payoff between submitting to journal H and L for an author having a paper with quality q. We have:

(5) $D(q)=M_H(q)-M_L(q)=\pi_H(q)B_H-\pi_L(q)B_L-(P_H-P_L)$

(6) $D'(q)=g(s_H-q)B_H-g(s_L-q)B_L$

By Lemma 1, there exist unique points q_0 and $\hat{q}_L$ such that $M_H(q_0)=0$ and $M_L(\hat{q}_L)=0$.

Under Assumption 4 or $B_H\in\left(\left(B_L+P_H-P_L\right),B_H^u\right]$, from Lemma 2 we know that $M_H(\hat{q}_L)<M_L(\hat{q}_L)=0$ or $D(\hat{q}_L)<0$. Since by definition $\hat{q}_H$ is such that $D(\hat{q}_H)=0$, from (5) we know that $\pi_H(\hat{q}_H)B_H=\pi_L(\hat{q}_H)B_L+(P_H-P_L)$ and have the following expression:

(7)
$$D'(\hat{q}_H)=g(s_H-\hat{q}_H)B_H-g(s_L-\hat{q}_H)B_L=\frac{g(s_H-\hat{q}_H)}{\pi_H}\pi_H B_H-\frac{g(s_L-\hat{q}_H)}{\pi_L}\pi_L B_L$$
$$=\frac{g(s_H-\hat{q}_H)}{\pi_H}(P_H-P_L)+\pi_L B_L[\frac{g(s_H-\hat{q}_H)}{\pi_H}-\frac{g(s_L-\hat{q}_H)}{\pi_L}]$$

Because $s_H-\hat{q}_H>s_L-\hat{q}_H$, then by Assumption 3 we have

$$h(s_H-\hat{q}_H)=\frac{g(s_H-\hat{q}_H)}{1-G(s_H-\hat{q}_H)}=\frac{g(s_H-\hat{q}_H)}{\pi_H}>h(s_L-\hat{q}_H)=\frac{g(s_L-\hat{q}_H)}{1-G(s_L-\hat{q}_H)}=\frac{g(s_L-\hat{q}_H)}{\pi_L}.$$

Since $P_H\geq P_L$, from (7) we know that $D'(\hat{q}_H)>0\ \ \forall D(\hat{q}_H)=0$, thus there is a single crossing point $\hat{q}_H$ between $M_H(q)$ and $M_L(q)$. Because $M_j(q)$ ($j=H,L$) is monotonically increasing and $q_0>\hat{q}_L$ by Lemma 3, the curves of $M_H(q)$ and $M_L(q)$ can be shown in figure 2.

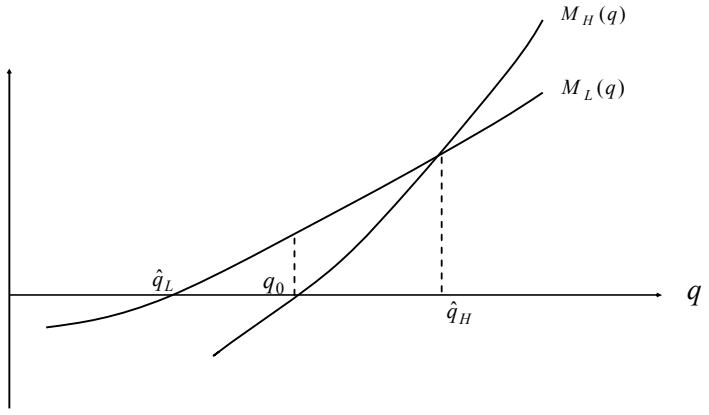

Figure 2: Expected payoffs of submitting to journal H, L

There exists exactly one point $\hat{q}_H$ such that $D(\hat{q}_H) = 0$ or $M_H(\hat{q}_H) = M_L(\hat{q}_H)$. Since $q_0 > \hat{q}_L$ and $D'(\hat{q}_H) > 0$, we know that $M_H(\hat{q}_H) = B_H[1 - G(s_H - \hat{q}_H)] - P_H > 0$ and $\hat{q}_H > \hat{q}_L$. Thus,

i) When $q > \hat{q}_H$, $M_H(q) > M_L(q)$ and $M_H(q) > 0$

ii) When $q \in [\hat{q}_L, \hat{q}_H)$, $M_H(q) > M_L(q)$ and $M_L(q) \geq 0$

iii) When $q \in (-\infty, \hat{q}_L)$, $M_H(q) < 0$ and $M_L(q) < 0$

(Q.E.D)

Therefore, the author who has a paper with the quality $q = \hat{q}_H$ is indifferent between submitting his paper to the high or to the low quality journal. For $q \in (\hat{q}_H, +\infty)$, we know that

$M_H(q) > M_L(q)$, so it's more profitable to submit a paper with quality greater than $\hat{q}_H$ to the high quality journal. Also, the expected payoff of submitting to the high quality journal is positive, thus the optimal strategy is to submit the paper to journal H. For $q \in [\hat{q}_L, \hat{q}_H)$, we have $M_H(q) < M_L(q)$ and $M_L(q) \geq 0$, thus submitting the paper to journal L is the dominant strategy. For $q \in (-\infty, \hat{q}_L)$, it's that $M_H(q) < 0$ and $M_L(q) < 0$, so papers with qualities in this range will not be submitted to either journal.

According to proposition 1, we know that the expected number of submissions to journal H and L are $N_H = N[1 - F(\hat{q}_H)]$ and $N_L = N[F(\hat{q}_H) - F(\hat{q}_L)]$ respectively. In addition, we can derive the following corollary 1 and 2 from proposition 1.

Corollary 1: $\left(d\hat{q}_H / dB_H\right) < 0$ and $\hat{q}_H\left(B_H^u\right) = \hat{q}_L$

Proof:

Since $D(\hat{q}_H, B_H) = \pi_H(\hat{q}_H)B_H - \pi_L(\hat{q}_H)B_L - (P_H - P_L) = 0$, from the implicit function theorem we know $\left(d\hat{q}_H / dB_H\right) = -\dfrac{\partial D / \partial B_H}{\partial D / \partial \hat{q}_H}$. Because $(\partial D / \partial B_H) = \pi_H(\hat{q}_H) > 0$ and $D'(\hat{q}_H) > 0$ by the proof of proposition 1, we have $\left(d\hat{q}_H / dB_H\right) < 0$. Thus $\hat{q}_H$ is monotonically decreasing in B_H and there is a unique $\hat{q}_H$ for each B_H.

When $B_H = B_H^u$, by Lemma 3 we know that $q_0\left(B_H^u\right) = \hat{q}_L$ and $M_H(q_0(B_H^u)) = M_L(\hat{q}_L) = 0$. Since $\hat{q}_H$ is defined that $M_H = M_L$ and $\hat{q}_H$ is unique for each B_H, we have $\hat{q}_H\left(B_H^u\right) = \hat{q}_L$.

(Q.E.D)

Corollary 2: *The quality threshold for a paper to be submitted to the high quality journal increases more as the high quality journal's standard* s_H *rises (* $\frac{\partial \hat{q}_H}{\partial s_H} > 1$*) and decreases as the low quality journal's standard* s_L *rises (* $\frac{\partial \hat{q}_H}{\partial s_L} < 0$*). The quality threshold for a paper to be submitted to either the low quality journal or no submission doesn't depend on* s_H *and increases as* s_L *rises.*

Proof:

Since $D(\hat{q}_H) = \pi_H(\hat{q}_H)B_H - \pi_L(\hat{q}_H)B_L - (P_H - P_L) = 0$, we can derive:

(8) $$\frac{\partial \hat{q}_H}{\partial s_H} = \frac{B_H g(s_H - \hat{q}_H)}{B_H g(s_H - \hat{q}_H) - B_L g(s_L - \hat{q}_H)}$$

(9) $$\frac{\partial \hat{q}_H}{\partial s_L} = \frac{B_L g(s_L - \hat{q}_H)}{B_L g(s_L - \hat{q}_H) - B_H g(s_H - \hat{q}_H)}$$

We know $D'(\hat{q}_H) = B_H g(s_H - \hat{q}_H) - B_L g(s_L - \hat{q}_H) > 0$. Because $g(s_H - \hat{q}_H) > 0$ and $g(s_L - \hat{q}_H) > 0$, we have $0 < B_H g(s_H - \hat{q}_H) - B_L g(s_L - \hat{q}_H) < B_H g(s_H - \hat{q}_H)$, thus $\frac{\partial \hat{q}_H}{\partial s_H} = \frac{B_H g(s_H - \hat{q}_H)}{B_H g(s_H - \hat{q}_H) - B_L g(s_L - \hat{q}_H)} > 1$ and $\frac{\partial \hat{q}_H}{\partial s_L} = \frac{B_L g(s_L - \hat{q}_H)}{B_L g(s_L - \hat{q}_H) - B_H g(s_H - \hat{q}_H)} < 0$.

Since $M_L(\hat{q}_L) = \pi_L(\hat{q}_L)B_L - P_L = 0$, we can derive:

(10) $$\frac{\partial \hat{q}_L}{\partial s_H} = 0$$

(11) $$\frac{\partial \hat{q}_L}{\partial s_L} > 0$$

(Q.E.D)

As journal H 's quality standard rises, the quality threshold of submitting a paper to journal H also increases, thus the marginal author who is originally indifferent between submitting his paper to either journal will switch to journal L and the expected submissions to journal H will decrease. Also, as journal L 's quality standard rises, the quality threshold for a paper to be submitted to journal H will decrease, thus this marginal author will switch to journal H and N_H increases. Together with (11) and (12), we know as s_H increases, the expected submissions to journal L increase and as s_L increases, the expected submissions to journal L decrease.

3.1.2 Multiple submissions

Now we allow an author to submit his paper to the two journals simultaneously but continue to assume there is only one period. There are four possibilities when the paper is submitted to both journals: 1) the paper is accepted by both journals; 2) it is accepted by journal H but rejected by journal L; 3) it is accepted by journal L but rejected by journal H; 4) it is rejected by both journals. If the paper is accepted by both journals, the author can only choose one journal to publish his paper, and he will always choose the high quality journal since he gets a higher publication benefits from journal H, i.e., $B_H > B_L$. Thus, if an author submits his paper to both journals, his expected payoff is as follows:

$$(12)\quad M_{H,L}(q) = \pi_H(q)B_H + [1-\pi_H(q)]\pi_L(q)B_L - (P_H + P_L)$$

This expected payoff is an increasing function of the paper's quality since

$$\begin{aligned} M'_{H,L}(q) &= B_H g(s_H - q) + B_L g(s_L - q)G(s_H - q) - B_L[1-G(s_L - q)]g(s_H - q) \\ &> B_H g(s_H - q) - B_L[1-G(s_L - q)]g(s_H - q) \\ &= g(s_H - q)\{B_H - B_L[1-G(s_L - q)]\} > g(s_H - q)(B_H - B_L) > 0 \end{aligned} \quad (13)$$

Assumption 5: $B_L > 4P_L$

Define $\tilde{D}(q) \equiv M_H(q) - M_{H,L}(q)$, which is the difference in the expected payoff between submitting to only journal H and submitting to both journals; Define $K(B_H) = \tilde{D}(q)\big|_{q=\hat{q}_H(B_H)}$

Lemma 4: If $B_L > 4P_L$, there exist q', q'' s.t. $\tilde{D}(q) > 0$ for $q \in (-\infty, q') \cup (q'', \infty)$ and $\tilde{D}(q) < 0$ for $q \in (q', q'')$

Proof:

(14) $\tilde{D}(q) = M_H(q) - M_{H,L}(q) = P_L - [1 - \pi_H(q)]\pi_L(q)B_L$

Under Assumption 2, we know that $\lim_{q \to -\infty} \tilde{D}(q) = P_L > 0$ and $\lim_{q \to +\infty} \tilde{D}(q) = P_L > 0$

Since $\frac{d\pi_L}{dq} = g(s_L - q)$ and $\frac{d^2\pi_L}{dq^2} = -g'(s_L - q)$, we know that:

(15) $\frac{d\tilde{D}(q)}{dq} = \{\pi'_H \pi_L - (1 - \pi_H)\pi'_L\} B_L$

(16) $\frac{d^2\tilde{D}(q)}{dq^2} = \{2\pi'_H \pi_L{}' + \pi''_H \pi_L - (1 - \pi_H)\pi''_L\} B_L$

Evaluating $\frac{d^2\tilde{D}(q)}{dq^2}$ at $\frac{d\tilde{D}(q)}{dq} = 0$ yields:

(17) $\frac{d^2\tilde{D}(q)}{dq^2}\Big|_{(d\tilde{D}/dq)=0} = \left\{ -\frac{\pi'_H \pi_L \pi''_L}{\pi_L{}'} + 2\pi'_H \pi_L{}' + \pi''_H \pi_L \right\} B_L = \left\{ 2\pi'_H \pi_L{}' + \pi_L \pi'_H \left[\frac{\pi''_H}{\pi'_H} - \frac{\pi''_L}{\pi'_L} \right] \right\} B_L$

Define $y(\alpha) \equiv \ln[g(\alpha)]$, then $y'(\alpha) = \frac{g'(\alpha)}{g(\alpha)}$. By Assumption 3 or the log-concavity of the density function g, we know that $y''(\alpha) \le 0$ or $\frac{g'(\alpha)}{g(\alpha)}$ is decreasing (non-increasing) in α.

Then $\left[\frac{\pi_H''}{\pi_H'}-\frac{\pi_L''}{\pi_L'}\right]=\frac{g'(s_L-q)}{g(s_L-q)}-\frac{g'(s_H-q)}{g(s_H-q)}>0$ since $s_H-q>s_L-q$. Because $\pi_H', \pi_L{}'>0$ and $\pi_L>0$, we know that $\left.\frac{d^2\tilde{D}(q)}{dq^2}\right|_{(d\tilde{D}/dq)=0}>0$.

Combined with $\lim_{q\to-\infty}\tilde{D}(q)=P_L>0$ and $\lim_{q\to+\infty}\tilde{D}(q)=P_L>0$, we know that there are either zero or two values of q s.t. $\tilde{D}(q)=0$. For P_L sufficiently large (e.g. $P_L>B_L$), $\tilde{D}(q)=P_L-[1-\pi_H(q)]\pi_L(q)B_L>P_L-B_L>0$ and $\tilde{D}$ will be positive everywhere. On the other hand, for $P_L<\frac{B_L}{4}$ there must be a domain in which $\tilde{D}<0$. Because at $\hat{q}$ $s.t.\ \pi_L(\hat{q})=(1/2)$, $\pi_H(\hat{q})<\pi_L(\hat{q})=(1/2)\to(1-\pi_H(\hat{q}))\pi_L(\hat{q})>(1/4)\to\tilde{D}(\hat{q})<P_L-\frac{B_L}{4}<0$. Since $\tilde{D}(-\infty)=\tilde{D}(\infty)>0$ and $\tilde{D}(\hat{q})<0$, $\tilde{D}$ must achieve a (local) minimum somewhere in $q\in(-\infty,\infty)$.

The beginning analysis in this proof shows that whenever $\frac{d\tilde{D}}{dq}=0$, $\frac{d^2\tilde{D}}{dq^2}>0$, which implies that given continuity of $\frac{d\tilde{D}}{dq}$, there can be only one extreme point, and that extreme point is a minimum. Therefore, $\tilde{D}(q)$ can cross the zero axis at most twice. And under the assumption $P_L<\frac{B_L}{4}$, there will be two roots q' and q'' to the equation $\tilde{D}(q)=0$. We know that $\tilde{D}(q)>0$ for $q\in(-\infty,q')\cup(q'',\infty)$ and $\tilde{D}(q)<0$ for $q\in(q',q'')$.

(Q.E.D)

Lemma 5: There exist $B_H^1 \in \left(B_L + P_H - P_L, \tilde{B}_H\right)$ and $B_H^2 \in \left(\tilde{B}_H, B_H^u\right)$, where $\pi_L\left(\tilde{B}_H\right) = 1/2$, s.t. $\tilde{D}\left(\hat{q}_H\right) < 0$ for $B_H \in \left(B_H^1, B_H^2\right)$

Proof:

By definition, $K\left(B_H, \hat{q}_H\left(B_H\right)\right) \equiv M_H\left(B_H, \hat{q}_H\left(B_H\right)\right) - M_{HL}\left(B_H, \hat{q}_H\left(B_H\right)\right)$,

then $K\left(B_H, \hat{q}_H\left(B_H\right)\right) = \tilde{D}\left(\hat{q}_H\right) = P_L - [1 - \pi_H(\hat{q}_H\left(B_H\right))]\pi_L(\hat{q}_H\left(B_H\right))B_L$.

By Corollary 1 we know that $\left(d\hat{q}_H / dB_H\right) < 0$, thus $\dfrac{d\pi_L\left(\hat{q}_H\left(B_H\right)\right)}{dB_H} = \left(\dfrac{\partial \pi_L}{\partial \hat{q}_H}\right)\left(\dfrac{d\hat{q}_H}{dB_H}\right) < 0$.

If $B_L > 4P_L$, then $\pi_L\left(\hat{q}_L\right) = \dfrac{P_L}{B_L} < \dfrac{1}{4}$. Because $\lim_{B_H \to (B_L + P_H - P_L)^+} \pi_L\left(\hat{q}_H\left(B_H\right)\right) = 1$ since $\hat{q}_H \to \infty$ and $\lim_{B_H \to B_H^u} \pi_L\left(\hat{q}_H\left(B_H\right)\right) = \dfrac{P_L}{B_L} < (1/4)$ since $\hat{q}_H \to \hat{q}_L$, we know $\pi_L\left(\hat{q}_H\left(B_H\right)\right)$ is a monotonically decreasing function of B_H with upper bound of one, and lower bound less than $(1/4)$. Thus, there must exist a unique $\tilde{B}_H \in \left(\left(B_L + P_H - P_L\right), B_H^u\right]$ s.t. $\pi_L\left(\tilde{B}_H\right) = 1/2$.

Further,

$$K\left(\hat{q}_H\left(\tilde{B}_H\right)\right) = P_L - \left[\left(1 - \pi_H\left(\hat{q}_H\right)\right)\pi_L\left(\hat{q}_H\right)B_L\right] < P_L - \left[\left(1 - \pi_L\left(\hat{q}_H\right)\right)\pi_L\left(\hat{q}_H\right)B_L\right] < P_L - \frac{B_L}{4} < 0$$

By Lemma 3 we know that $\hat{q}_H \to \infty$ as $B_H \to \left(B_L + P_H - P_L\right)^+$, thus $\lim_{B_H \to (B_L + P_H - P_L)^+} K\left(\hat{q}_H\left(B_H\right)\right) = P_L > 0$ since $\pi_H\left(\hat{q}_H\right) \to 1$. By Corollary 1 we know that $\hat{q}_H(B_H^u) = \hat{q}_L$, thus

$$\lim_{B_H \to B_H^u} K\left(\hat{q}_H\left(B_H\right)\right) = P_L - \left[\left(1 - \pi_H\left(\hat{q}_L\right)\right)\pi_L\left(\hat{q}_L\right)\right]B_L = \left(P_L - \pi_L\left(\hat{q}_L\right)B_L\right) + \pi_L\left(\hat{q}_L\right)\pi_H\left(\hat{q}_L\right)B_L > 0$$

since $\left(P_L - \pi_L(\hat{q}_L)B_L\right) = 0$. From previous analysis in Lemma 4, we know that

$\left.\frac{d^2\tilde{D}(q)}{dq^2}\right|_{(d\tilde{D}/dq)=0} > 0$. Since $K\left(B_H, \hat{q}_H(B_H)\right) = \tilde{D}(\hat{q}_H) = P_L - [1-\pi_H(\hat{q}_H(B_H))]\pi_L(\hat{q}_H(B_H))B_L$,

using the same approach we will have $\left.\frac{d^2K}{d\hat{q}_H^2}\right|_{(dK/d\hat{q}_H)=0} > 0$. Thus, K has at most one extreme point, which is the minimum, and K can cross the zero axis at most twice. For the assumption $P_L < \frac{B_L}{4}$, there are two roots to the equation $K\left(\hat{q}_H(B_H)\right) = 0$. By Corollary 1 we know that $\hat{q}_H(B_H)$ is a monotonically decreasing function of B_H. Thus, there exist exactly two points B_H^1 and B_H^2, s.t. $K\left(\hat{q}_H\left(B_H^1\right)\right) = 0$ and $K\left(\hat{q}_H\left(B_H^2\right)\right) = 0$,

where $B_H^1 \in \left(B_L + P_H - P_L, \tilde{B}_H\right)$, $B_H^2 \in \left(\tilde{B}_H, B_H^U\right)$. Therefore, when $B_H \in \left(B_H^1, B_H^2\right)$, we have $K(B_H) < 0$ or $\tilde{D}(\hat{q}_H) < 0$.

(Q.E.D)

From Lemma 4 and 5, we know that there exist a domain for B_H such that $\tilde{D}(\hat{q}_H(B_H)) < 0$ or $M_H(\hat{q}_H) < M_{H,L}(\hat{q}_H)$. Since $M_H(\hat{q}_H) = M_L(\hat{q}_H)$ at $\hat{q}_H$, by continuity there will be a domain for paper's quality such that $Max\{M_L, M_H, M_{HL}\} = M_{H,L}$.

Assumption 6: $B_H \geq 2B_L$

The submission strategy for an author having a paper with quality q depends on the relative magnitude of $M_H(q)$, $M_L(q)$ and $M_{H,L}(q)$. An author's optimal submission strategy in "multiple-submission and single period" case can be summarized in the following proposition 2.

Proposition 2:

Given s_H and s_L, when Assumptions 1- 6 hold, there exist quality thresholds q_2, q_3, $\hat{q}_H$ and $\hat{q}_L$ such that an author has the following submission strategy.

1) If the paper's quality satisfies $q \in [q_2, +\infty)$, submit it to journal H only.
2) If the paper's quality satisfies $q \in [q_3, q_2)$, submit it to journal H and L simultaneously.
3) If the paper's quality satisfies $q \in [\hat{q}_L, q_3)$, submit it to journal L only.
4) If the paper's quality satisfies $q \in (-\infty, \hat{q}_L)$, no submission.

Where $M_H(q_2) = M_{H,L}(q_2)$, $M_{H,L}(q_3) = M_L(q_3)$, $M_H(\hat{q}_H) = M_L(\hat{q}_H)$ and $M_L(\hat{q}_L) = 0$.

Proof:

By definition we have $\tilde{D}(q) \equiv M_H(q) - M_{H,L}(q)$ and

$K\left(B_H, \hat{q}_H\left(B_H\right)\right) \equiv M_H\left(B_H, \hat{q}_H\left(B_H\right)\right) - M_{HL}\left(B_H, \hat{q}_H\left(B_H\right)\right)$. Under Assumption 5 or $B_L > 4P_L$, according to Lemma 5 we know that there exist B_H^1 and B_H^2, s.t.

$K\left(\hat{q}_H\left(B_H^1\right)\right) = 0$, $K\left(\hat{q}_H\left(B_H^2\right)\right) = 0$ and $K\left(\hat{q}_H(B_H)\right) < 0$ for $B_H \in \left(B_H^1, B_H^2\right)$,

where $B_H^1 \in \left(B_L + P_H - P_L, \tilde{B}_H\right), B_H^2 \in \left(\tilde{B}_H, B_H^U\right)$ and $\pi_L\left(\tilde{B}_H\right) = 1/2$. Define $q_2 \equiv \hat{q}_H\left(B_H^1\right)$, then $q_2 > \hat{q}_H(B_H)$ for $B_H \in \left(B_H^1, B_H^2\right)$ since $\left(d\hat{q}_H / dB_H\right) < 0$.

From the proof of Lemma 4, we know that $\tilde{D}(q)$ can cross the zero axis at most twice, thus we have $\tilde{D}(q) > 0$ when $q \in (q_2, +\infty)$ and $\tilde{D}(q) \le 0$ when $q \in (\hat{q}_H, q_2]$. So, for $q \in (q_2, +\infty)$ $Max\{M_L, M_H, M_{HL}\} = M_H$ and submitting to the high quality journal is the dominant strategy; for $q \in (\hat{q}_H, q_2]$ $Max\{M_L, M_H, M_{HL}\} = M_{H,L}$ and submitting to both journals is the dominant strategy.

Define $\hat{D}(q) \equiv M_{H,L}(q) - M_L(q)$, which is the difference of the expected payoff between submitting to both journals and only journal L for an author having a paper with quality q.

Since $M_H(q) = \pi_H B_H - P_H$, $M_L(q) = \pi_L B_L - P_L$ and

$M_{H,L}(q) = \pi_H(q) B_H + [1 - \pi_H(q)]\pi_L(q) B_L - (P_H + P_L)$, we have:

(18) $\hat{D}(q) = \pi_H(B_H - \pi_L B_L) - P_H$

(19) $\hat{D}'(q) = B_H \pi'_H - \pi'_H \pi_L B_L - \pi_H \pi'_L B_L$

When Assumption 3 holds, we know that $\frac{g(s_H - q)}{1 - G(s_H - q)} > \frac{g(s_L - q)}{1 - G(s_L - q)}$ since log-concave density functions have the monotone increasing hazard functions[3]. Then we have

(20) $g(s_H - q)[1 - G(s_L - q)] > g(s_L - q)[1 - G(s_H - q)]$ or $\pi'_H \pi_L > \pi_H \pi'_L$

From (19), we know

(21) $\hat{D}'(q) > B_H \pi'_H - 2\pi'_H \pi_L B_L = \pi'_H(B_H - 2\pi_L B_L) \geq \pi'_H(B_H - 2B_L)$

When Assumption 6 holds or $B_H \geq 2B_L$, we have $\hat{D}'(q) > 0$ or the difference between $M_{H,L}(q)$ and $M_L(q)$ is monotonically increasing in q. When $q \leq q_0$, since $M_H(q) = \pi_H(q) B_H - P_H \leq 0$ we know that:

(22) $M_{H,L}(q) = \pi_H B_H - P_H + (1 - \pi_H)\pi_L B_L - P_L \leq (1 - \pi_H)\pi_L B_L - P_L < \pi_L B_L - P_L = M_L(q)$

So $M_{H,L}(q_0) < M_L(q_0)$ or $\hat{D}(q_0) < 0$.

[3] The monotone increasing hazard rate property discussed here is similar as the strict monotone likelihood ratio property (MLRP) discussed in the paper "The Decentralized College Admissions Problem with Frictions" authored by Hector Chade, Gregory Lewis and Lones Smith. The strict MLRP holds if the density function g is log-concave.

When $B_L > 4P_L$, from Lemma 4 we know that there exists $B_H^1 \in \left(B_L + P_H - P_L, \tilde{B}_H\right)$ and $B_H^2 \in \left(\tilde{B}_H, B_H^U\right)$, where $\pi_L\left(\tilde{B}_H\right) = 1/2$,s.t. $K\left(B_H\right) < 0$ for $B_H \in \left(B_H^1, B_H^2\right)$. So if $B_H \in \left(B_H^1, B_H^2\right)$, we have $K\left(B_H\right) = M_H\left(\hat{q}_H\right) - M_{HL}\left(\hat{q}_H\right) < 0$ thus $M_L\left(\hat{q}_H\right) = M_H\left(\hat{q}_H\right) < M_{HL}\left(\hat{q}_H\right)$ or $\hat{D}(\hat{q}_H) = M_{HL}\left(\hat{q}_H\right) - M_L\left(\hat{q}_H\right) > 0$

Since $\hat{D}(q_0) < 0$, $\hat{D}(\hat{q}_H) > 0$ and $\hat{D}'(q) > 0$, there must exist exactly one point $q_3 \in (q_0, \hat{q}_H)$ such that $M_{H,L}(q_3) = M_L(q_3)$, in other words $M_{H,L}(q)$ crosses $M_L(q)$ only once at q_3. From $\hat{D}'(q) > 0$ and $\hat{D}(q_3) = 0$, we know that:

i) When $q > q_3$, $M_{H,L}(q) > M_L(q)$

ii) When $q \le q_3$, $M_{H,L}(q) \le M_L(q)$

When $q \in (q_3, \hat{q}_H]$, we know that $M_{H,L}(q) > M_L(q) \ge M_H(q) > 0$, so $Max\{M_L, M_H, M_{HL}\} = M_{H,L} > 0$ and submitting the paper to both journals is the dominant strategy. When $q \in (\hat{q}_L, q_3]$, we have $M_{H,L}(q) \le M_L(q)$ and $M_H(q) < M_L(q)$ since $q_3 < \hat{q}_H$, thus $Max\{M_L, M_H, M_{HL}\} = M_L > M_L(\hat{q}_L) = 0$ and submitting the paper to only journal L is the dominant strategy. When $q \le \hat{q}_L$, $Max\{M_L, M_H, M_{HL}\} = M_L < 0$, the paper will not be submitted.

(Q.E.D)

Therefore,

i) When $q \in [q_2, +\infty)$, we know that $M_H(q) > M_{H,L}(q)$ and $M_H(q) > M_L(q)$ since $q_2 > \hat{q}_H$, thus an author having a paper with quality no less than q_2 will choose to submit his paper to only the high quality journal.

ii) When $q \in [q_3, q_2)$, we know $M_{H,L}(q) \geq M_L(q)$ and $M_{H,L}(q) > M_H(q)$. Thus, submitting the paper to both journals simultaneously is the dominant strategy for an author having a paper with quality in this range.

iii) When $q \in [\hat{q}_L, q_3)$, we have $M_{H,L}(q) < M_L(q)$ and $M_H(q) < M_L(q)$ since $q_3 < \hat{q}_H$ ($M_H(q) < M_L(q)$ when $q < \hat{q}_H$ according to proposition 1). Also, we know $M_L(q) \geq 0$ when $q \geq \hat{q}_L$ from proposition 1, so submitting the paper to journal L is the dominant strategy.

iv) When $q \in (-\infty, \hat{q}_L)$, we know that $M_{H,L}(q) < M_L(q) < 0$ and $M_H(q) < M_L(q) < 0$, thus the paper will never be submitted to either journal.

The curves of $M_H(q)$, $M_L(q)$ and $M_{H,L}(q)$ are illustrated in figure 3

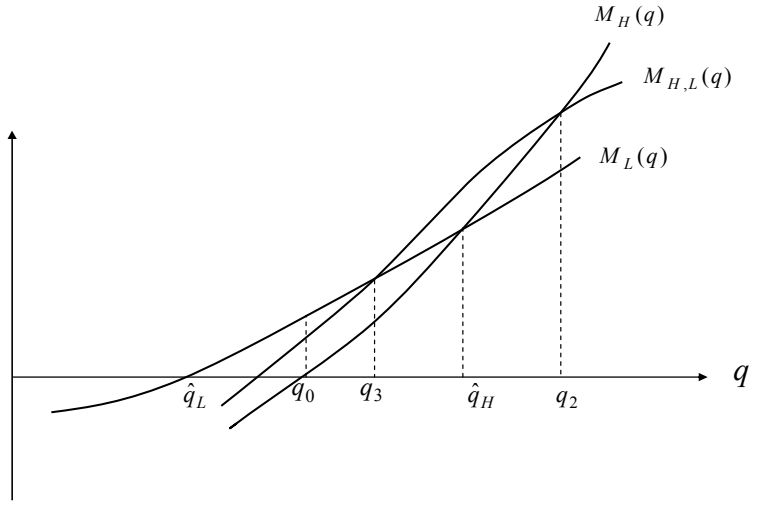

Figure 3: Expected payoffs of submitting to journal H, L and both

In the case of "single submission" only the papers with quality $q \in [\hat{q}_H, +\infty)$ will be submitted to the high quality journal, but if multiple submissions were allowed, the submissions to journal H also include the papers with quality $q \in [q_3, \hat{q}_H)$. In addition, the submissions to journal L will include all papers with quality $q \in [\hat{q}_H, q_2)$, as compared to papers with quality $q \in [\hat{q}_L, \hat{q}_H)$ in the single submission case. Allowing multiple submissions is like giving the authors an option and whether they choose to exercise the option or not depends on the realization of their paper's quality. According to the equilibrium submission strategy analyzed above, we know that if an author has a paper with quality below but close to the high quality threshold $\hat{q}_H$ (e.g., $q \in [q_3, \hat{q}_H)$), he will choose to exercise this option and to simultaneously submit his paper to both journals. Similarly, if an author has a paper with quality above but close to $\hat{q}_H$ (e.g., $q \in [\hat{q}_H, q_2)$), he will choose multiple submission in case his paper is rejected by the high quality

journal but still has a chance of being accepted by journal L. But if the paper's quality is already relatively high ($q > q_2$) or relatively low ($q < q_3$), the author will not choose multiple submissions. Therefore, in this case the expected number of submissions to both the high and low quality journals will increase compared with "single submission" and the expected number of non-submitted papers doesn't change.

3.2 Submission strategy in multi-period horizon

So far, we have investigated the authors' submission strategies in the situation of both single and multiple submissions. But the analysis has been in a one period framework, if a paper gets rejected the life of the paper ends. In reality, a rejected paper may be resubmitted by its author in the next period. In this section, we will investigate the so called "sequential submission" in an infinite time horizon and discuss the authors' optimal submission strategy in both the case of single and multiple submissions. We assume that there are an infinite number of periods and each author produces one paper per period. Suppose each period the author can submit his new paper to only one journal, and if the paper is rejected he can resubmit it to the other journal in the following period, but if it is rejected again he cannot submit this paper any more in the future. Thus every paper can be submitted at most twice since there are only two journals. In other words, if a paper is rejected twice the life ends for the paper. An author may face two decisions in each period: 1) whether and where to submit his new paper; 2) if he has a paper rejected in last period, whether to resubmit this old paper. So the submitted papers in each period may include newly produced ones and the old ones which were rejected in last period.

3.2.1 Single submission

Suppose each period an author can submit his paper to only one journal. When the paper is rejected he can resubmit it in the following period, but the resubmitted journal can not be the same one as in the previous period. Thus, every paper can be submitted at most twice since there are only two journals. In other words, if a paper is rejected twice, the life ends for this paper. An author who has a new paper faces two decisions: 1) whether and where to submit the paper in the current period; 2) if the paper was rejected, whether to resubmit it in next period. The decision tree is shown in figure 4, where period $t = 1, 2$ represents the first and second period; actions H , L and N represent submitting to high quality journal, low quality journal and no submission; states A , R represent being "accepted" or " rejected" respectively.

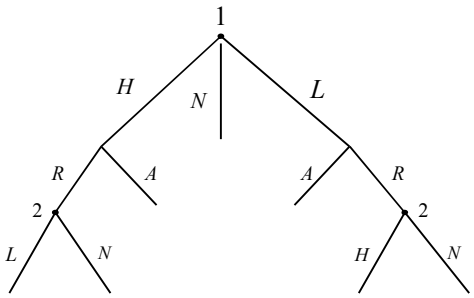

Figure 4: "Decision tree" of single submission

For a paper with quality q , in period $t = 2$ the expected payoff of submitting the paper to journal H or L is as follows:

(23) $M_H(q) = \pi_H(q) B_H - P_H$

(24) $M_L(q) = \pi_L(q)B_L - P_L$

According to (4), we know that $M_H(q)$ and $M_L(q)$ are monotonically increasing in q. From the analysis in section 3, we know the two curves of $M_H(q)$ and $M_L(q)$ can be shown in figure 5, and $M_H(q_0) = 0$, $M_L(\hat{q}_L) = 0$. Thus, in period $t = 2$ if a paper with quality $q > q_0$ is submitted to the high quality journal, the author gets a positive expected payoff .Also, if a paper with quality $q > \hat{q}_L$ is submitted to the low quality journal, the author gets a positive expected payoff. According to proposition 1, we also know that $M_H(q) > M_L(q)$ when $q > \hat{q}_H$ and vice versa.

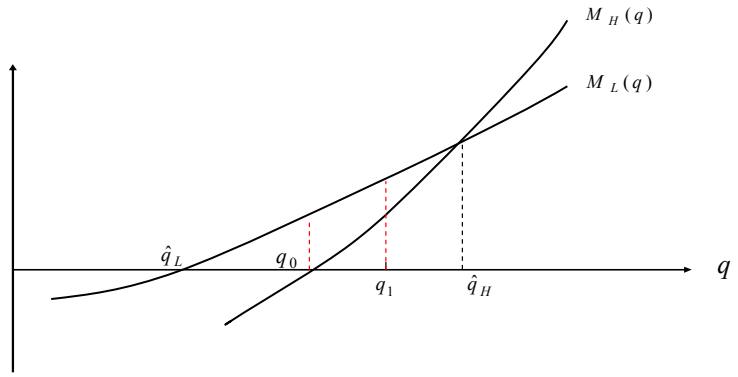

Figure 5: Expected payoffs of submitting to journal H, L in period 2

Suppose every author has the same discount factor $\delta \in [0,1]$. In period $t = 1$, the expected payoff of submitting the paper to journal H or L is as follows:

(25) $$\begin{aligned} M_{1H}(q) &= \pi_H(q)B_H - P_H + \delta[1 - \pi_H(q)]Max\{M_L(q), 0\} \\ &= M_H(q) + \delta[1 - \pi_H(q)]Max\{M_L(q), 0\} \end{aligned}$$

(26) $$\begin{aligned} M_{1L}(q) &= \pi_L(q)B_L - P_L + \delta[1-\pi_L(q)]Max\{M_H(q),0\} \\ &= M_L(q) + \delta[1-\pi_L(q)]Max\{M_H(q),0\} \end{aligned}$$

Therefore, for an author having a paper with quality q, where to submit his paper in the first period depends on the relative magnitude of $M_{1H}(q)$ and $M_{1L}(q)$ or the sign of $D_1(q) \equiv M_{1H}(q) - M_{1L}(q)$. The author's optimal submission strategy in "single submission and multiple-period" case is summarized in the following proposition 3 and illustrated in table 2.

Proposition 3:

Given s_H and s_L, when Assumptions 1- 6 hold, there exist quality thresholds q_1, q_0 and $\hat{q}_L$ such that an author has the following submission strategy.

1) When $q \in [q_1, +\infty)$, submit it to journal H in first period; if rejected, then resubmit it to journal L in second period;
2) When $q \in [q_0, q_1)$, submit it to journal L in first period; if rejected, then resubmit it to journal H in second period;
3) When $q \in [\hat{q}_L, q_0)$, submit it to journal L in first period; if rejected, no resubmission.
4) When $q \in (-\infty, \hat{q}_L)$, never submit it to either journal.

Where $M_{1H}(q_1) = M_{1L}(q_1)$, $M_H(q_0) = 0$, $M_L(\hat{q}_L) = 0$ and $M_H(\hat{q}_H) = M_L(\hat{q}_H)$

Proof:

When $q \in [\hat{q}_H, +\infty)$, from proposition 1 we know that $M_H(q) \geq M_L(q) > 0$, so $Max\{M_L(q),0\} = M_L(q)$ and $Max\{M_H(q),0\} = M_H(q)$. We define:

(27) $D_1(q) \equiv M_{1H}(q) - M_{1L}(q)$.

Thus, in period $t=1$ the difference in the expected payoff between submitting to journal H and L is as follows:

(28) $M_{1H}(q)-M_{1L}(q)=\{1-\delta[1-\pi_L(q)]\}M_H(q)-\{1-\delta[1-\pi_H(q)]\}M_L(q)$

Since $0\le\pi_H(q)<\pi_L(q)\le 1$ [4] and $\delta\in(0,1]$, then $1-\delta[1-\pi_L(q)]>1-\delta[1-\pi_H(q)]\ge 0$. This implies that if $M_H(q)\ge M_L(q)>0$, then $M_{1H}(q)-M_{1L}(q)>0$. Thus the optimal strategy for an author having a paper with quality $q\in[\hat{q}_H,+\infty)$ is that:

i) To submit the paper to the high quality journal in first period.

ii) If it is rejected, then resubmit it to the low quality journal in second period since $M_L(q)>0$.

When $q\in[q_0,\hat{q}_H)$, we know $M_L(q)>M_H(q)\ge 0$, so $Max\{M_L(q),0\}=M_L(q)$ and $Max\{M_H(q),0\}=M_H(q)$. From the previous analysis we know $D_1(\hat{q}_H)=M_{1H}(\hat{q}_H)-M_{1L}(\hat{q}_H)>0$. At $q=q_0$, we have $M_H(q_0)=0$ and $M_L(q_0)>0$, so $D_1(q_0)=M_{1H}(q_0)-M_{1L}(q_0)=-\{1-\delta[1-\pi_H(q_0)]\}M_L(q_0)<0$.

Since $D_1(\hat{q}_H)>0$ and $D_1(q_0)<0$, by continuity there exists $q_1\in(q_0,\hat{q}_H)$ *s.t.* $D_1(q_1)=0$. So that $D_1(q)=0$ has at least one root. We know that

(29) $D_1'(q)=\{1-\delta[1-\pi_L(q)]\}B_H\pi_H'-\{1-\delta[1-\pi_H(q)]\}B_L\pi_L'+\delta M_H\pi_L'-\delta M_L\pi_H'$

Evaluating at $D_1(q)=0$, we have

[4] $G(s_H-q)>G(s_L-q)\Rightarrow\pi_H(q)=1-G(s_H-q)<\pi_L(q)=1-G(s_L-q)$

$$D_1'(q) = \{1-\delta[1-\pi_L(q)]\}\pi_H' B_H - \{1-\delta[1-\pi_H(q)]\}\pi_L' B_L + \delta\pi_L' M_H - \delta\pi_H' M_L$$

$$(30) \quad = \left(\frac{\pi_H'}{\pi_H}\right)\{1-\delta[1-\pi_L(q)]\}\pi_H B_H - \left(\frac{\pi_L'}{\pi_L}\right)\{1-\delta[1-\pi_H(q)]\}\pi_L B_L$$

$$+\delta\left(\frac{\pi_L'}{\pi_L}\right)(\pi_L M_H) - \delta\left(\frac{\pi_H'}{\pi_H}\right)(\pi_H M_L)$$

Given $(\pi_i B_i) = M_i + P_i, \quad i = L, H$ and $\{1-\delta[1-\pi_L(q)]\}M_H(q) = \{1-\delta[1-\pi_H(q)]\}M_L(q)$ or

$\frac{M_H}{M_L} = \frac{1-\delta[1-\pi_H(q)]}{1-\delta[1-\pi_L(q)]}$ at $D_1(q) = 0$, rewrite (30) as:

$$D_1'(q) = \{1-\delta[1-\pi_L(q)]\}\left(\left(\frac{\pi_H'}{\pi_H}\right)(M_H + P_H) - \left(\frac{\pi_L'}{\pi_L}\right)\left(\frac{M_H}{M_L}\right)(M_L + P_L)\right)$$

$$(31) \quad -\delta\left[\left(\frac{\pi_H'}{\pi_H}\right)(\pi_H M_H)\left(\frac{1-\delta[1-\pi_L(q)}{1-\delta[1-\pi_H(q)}\right) - \left(\frac{\pi_L'}{\pi_L}\right)(\pi_L M_H)\right]$$

Simplifying (31), we have the following expression:

(32)

$$D_1'(q) = \{1-\delta[1-\pi_L(q)]\}\left\{\left(\frac{\pi_H'}{\pi_H}\right)P_H - \left(\frac{M_H}{M_L}\right)P_L\left(\frac{\pi_L'}{\pi_L}\right)\right\}$$

$$+\left(\frac{\pi_H'}{\pi_H}\right)M_H\{1-\delta[1-\pi_L(q)]\}\left\{1-\frac{\delta\pi_H}{\{1-\delta[1-\pi_H(q)]\}}\right\}$$

$$-\left(\frac{\pi_L'}{\pi_L}\right)M_H\{1-\delta[1-\pi_L(q)]\}\left\{1-\frac{\delta\pi_L}{\{1-\delta[1-\pi_L(q)]\}}\right\}$$

$$= \{1-\delta[1-\pi_L(q)]\}\left\{\left(\frac{\pi_H'}{\pi_H}\right)P_H - \left(\frac{M_H}{M_L}\right)P_L\left(\frac{\pi_L'}{\pi_L}\right)\right\} + M_H(1-\delta)\left\{\left(\frac{\pi_H'}{\pi_H}\right)\left[\frac{\{1-\delta[1-\pi_L(q)]\}}{\{1-\delta[1-\pi_H(q)]\}}\right] - \left(\frac{\pi_L'}{\pi_L}\right)\right\}$$

Since $\pi_H(q) < \pi_L(q)$ and $0 < \delta \le 1$, we have $\frac{M_H}{M_L} = \frac{1-\delta[1-\pi_H(q)]}{1-\delta[1-\pi_L(q)]} < 1$ at $D_1(q) = 0$. By Assumption 1 we have $P_H \ge P_L$ and by Assumption 3 we know that $\frac{\pi'(x)}{\pi(x)}$ is increasing in x (the hazard rate is increasing in x if the density function is log-concave). Thus, at $D_1(q) = 0$, $\left(\frac{\pi'_H}{\pi_H}\right)P_H - \left(\frac{M_H}{M_L}\right)P_L\left(\frac{\pi'_L}{\pi_L}\right) > \frac{\pi'_H}{\pi_H} - \frac{\pi'_L}{\pi_L} > 0$ and the first term in (32) is positive. Also, $\left(\frac{\pi'_H}{\pi_H}\right)\left(\frac{M_L}{M_H}\right) - (1-\delta)\left(\frac{\pi'_L}{\pi_L}\right) > \frac{\pi'_H}{\pi_H} - \frac{\pi'_L}{\pi_L} > 0$ and the second term in (32) is positive. Hence, $D'_1(q) > 0$ at $D_1(q) = 0$. Since $D_1(q_0) < 0$ and $D_1(\hat{q}_H) > 0$, there must exist a unique point $q_1 \in (q_0, \hat{q}_H)$ $s.t. D_1(q_1) = 0$

Thus, when $q \in [q_1, \hat{q}_H)$ we have $D_1(q) > 0$ and $M_L(q) > 0$, and the optimal submission strategy for the author is to submit the paper to the high quality journal in first period and resubmit it to the low quality journal in second period .When $q \in [q_0, q_1)$ we have $D_1(q) < 0$ and $M_H(q) > 0$, so the optimal submission strategy for the author is:

i) To submit the paper to the low quality journal in first period.

ii) If it is rejected, then resubmit it to the high quality journal in second period.

When $q \in [\hat{q}_L, q_0)$, $M_L(q) \ge 0 > M_H(q)$, so $Max\{M_L(q), 0\} = M_L(q)$ and $Max\{M_H(q), 0\} = 0$. Thus, we have:

(33) $M_{1H}(q) - M_{1L}(q) = M_H(q) - \{1-\delta[1-\pi_H(q)]\}M_L(q) < 0$

So the optimal strategy for an author having a paper with quality $q \in [\hat{q}_L, q_0)$ is:

i) To submit the paper to the low quality journal in first period.

ii) If it is rejected, do not submit to the high quality journal in second period.

When $q \in (-\infty, \hat{q}_L)$, we have $M_L(q) < 0$ and $M_H(q) < 0$ .Thus, the optimal strategy for an author having a paper with quality $q \in (-\infty, \hat{q}_L)$ is that they never submit the paper to either journal. Thus, the optimal submission strategy is as stated in the proposition.

(Q.E.D)

From proposition 3, we can derive the following Corollary 3.

Corollary 3: *The quality threshold for a paper to be submitted to the high quality journal in the first period decreases as the author's discount factor increases.*

Proof*:*

We know q_1 is determined by $D_1(q_1, \delta) = 0$ or

(34) $\{1-\delta[1-\pi_L(q_1)]\}M_H(q_1) - \{1-\delta[1-\pi_H(q_1)]\}M_L(q_1) = 0$, $q_1 \in [q_0, \hat{q}_H]$

According to the implicit function theorem:

(35) $\frac{dq_1}{d\delta} = -\frac{\partial D_1 / \partial \delta}{(\partial D_1 / \partial q)}|_{q=q_1}$

Then $\frac{\partial D_1}{\partial \delta}|_{q=q_1} = M_L(q_1)[1-\pi_H(q_1)] - M_H(q_1)[1-\pi_L(q_1)] > 0$ since $0 < 1-\pi_L(q_1) < 1-\pi_H(q_1)$

and $M_H(q_1) \le M_L(q_1)$ when $q_1 \in [q_0, \hat{q}_H]$. According to proposition 3, we know that $D_1(q)$ is monotonically increasing at q_1. Thus $\frac{\partial D_1}{\partial q}|_{q=q_1} > 0$, and we have $\frac{dq_1}{d\delta} < 0$.

(Q.E.D)

Table 2: Multi-period submission strategy in "single submission"

	$t=1$		$t=2$
$q \in [q_1, +\infty)$	H	$\xrightarrow{if \quad rejected}$	L
$q \in [q_0, q_1)$	L	$\xrightarrow{if \quad rejected}$	H
$q \in [\hat{q}_L, q_0)$	L	$\xrightarrow{if \quad rejected}$	N
$q \in (-\infty, \hat{q}_L)$	N		N

In every period an author may face two decisions: 1) whether and where to submit his new paper; 2) if he had a paper rejected in the last period, whether to resubmit this old paper. So the submitted papers in each period may include newly produced ones and the old ones which were rejected in the last period. According to table 2, we know that the per-period expected number of submissions to journal H is as follows:

$$
\begin{aligned}
N_H &= N[1-F(q_1)] + N[F(q_1)-F(q_0)]Prob(\alpha + q < s_L \mid q_0 \le q < q_1) \\
&= N[1-F(q_1)] + N[F(q_1)-F(q_0)]\frac{\int_{q_0}^{q_1} f(q)G(s_L-q)dq}{F(q_1)-F(q_0)} \qquad (36) \\
&= N[1-F(q_1)] + N[\int_{q_0}^{q_1} f(q)G(s_L-q)dq]
\end{aligned}
$$

The average quality of the papers accepted for publication in journal H is:

$$(37)\quad Q_H = \frac{\int_{q_1}^{+\infty} qf(q)[1-G(s_H-q)]dq + \int_{q_0}^{q_1} qf(q)G(s_L-q)[1-G(s_H-q)]dq}{\int_{q_1}^{+\infty} f(q)[1-G(s_H-q)]dq + \int_{q_0}^{q_1} f(q)G(s_L-q)[1-G(s_H-q)]dq}$$

Similarly, the expected per-period number of submissions to journal L is as follows:

$$\begin{aligned} N_L &= N[F(q_1)-F(\hat{q}_L)] + N[1-F(q_1)]Prob(\alpha+q<s_H \mid q\geq q_1) \\ &= N[F(q_1)-F(\hat{q}_L)] + N[1-F(q_1)]\frac{\int_{q_1}^{+\infty} f(q)G(s_H-q)dq}{1-F(q_1)} \\ &= N[F(q_1)-F(\hat{q}_L)] + N[\int_{q_1}^{+\infty} f(q)G(s_H-q)dq] \end{aligned} \quad (38)$$

The average quality of the papers accepted for publication in journal L is:

$$(39)\quad Q_L = \frac{\int_{\hat{q}_L}^{q_1} qf(q)[1-G(s_L-q)]dq + \int_{q_1}^{+\infty} qf(q)G(s_H-q)[1-G(s_L-q)]dq}{\int_{\hat{q}_L}^{q_1} f(q)[1-G(s_L-q)]dq + \int_{q_1}^{+\infty} f(q)G(s_H-q)[1-G(s_L-q)]dq}$$

Compared to the "one period case" analyzed in section 3, the expected per-period number of submissions to journal H increases and per period submissions to L is ambiguous. But for newly produced papers, it's straightforward to see from figure 5 that there are more submissions to journal H and fewer submissions to journal L since $q_1 \in (q_0, \hat{q}_H]$. Intuitively, if there is an opportunity of resubmission in the second period, some authors who choose journal L in the "one period case" will submit their papers to journal H in the first period and if rejected, can still get a positive expected payoff in the second period as long as the discount factor is greater than zero.

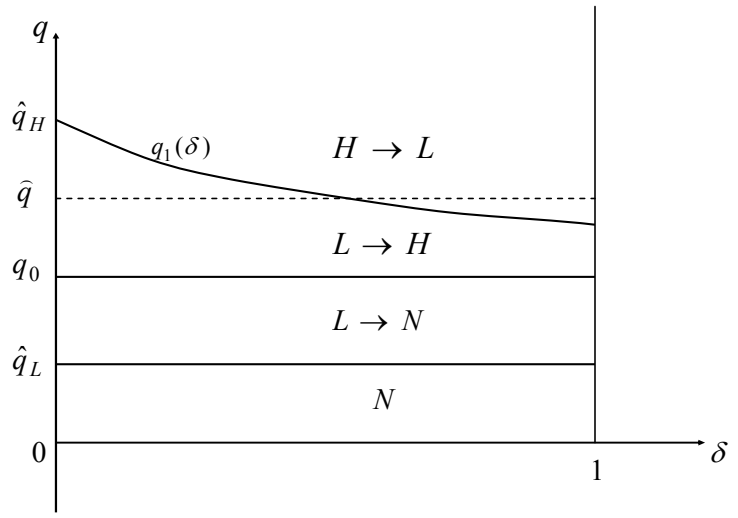

Figure 6: Submission strategy in "single submission" as δ changes

Figure 6 illustrates how the quality thresholds which determine an author's optimal submission strategy change as the discount factor changes. From Corollary 3, we know that q_1 increases as δ declines, which implies that given the paper's quality, as the author becomes less patient he will switch his submission strategy from the $H \to L$ area to the $L \to H$ area as shown in figure 5. For example, suppose there are two professors, one of them who has already received tenure and the other one who is an assistant professor. Assuming that their papers have the same quality level $\hat{q}$ which is shown in figure 6, it's more likely that the tenured professor will submit his paper to the high quality journal in the first period because he is more patient and cares more about the quality of the journal where his paper is going to be published. On the contrary, the assistant professor is more likely to submit his paper to the low quality journal in the first period so as to get a higher probability of being accepted for publication today. When $\delta = 0$, from $M_{1H}(q) - M_{1L}(q) = \{1 - \delta[1 - \pi_L(q)]\}M_H(q) - \{1 - \delta[1 - \pi_H(q)]\}M_L(q)$, we know $q_1 = \hat{q}_H$, thus

the submission strategy for the newly produced papers is exactly the same as the one period case illustrated in section 3.

3.2.2 Multiple submissions

In this case, we assume that in the paper's fist period, an author can choose to submit his new paper to one journal or to both journals. If the paper is submitted to only one journal and gets rejected by this journal, the author can resubmit it to a different journal in the following period. If the paper is submitted to both journals and gets rejected by both, the author cannot resubmit it in the future. Compared with the case analyzed in section 3.1, every paper can be submitted at most twice in both cases. The difference is that in the previous case each paper can be submitted to only one journal per period but in this case we allow multiple submissions. If an author simultaneously submits his paper to both journals in the first period, he loses the opportunity of resubmission in the second period. Thus, if he submits the paper to only one journal in this period, he can resubmit it in next period when it is rejected and gets a discounted expected payoff. So for an author there is a trade-off between choosing "single submission" and "multiple submissions" in the current period.

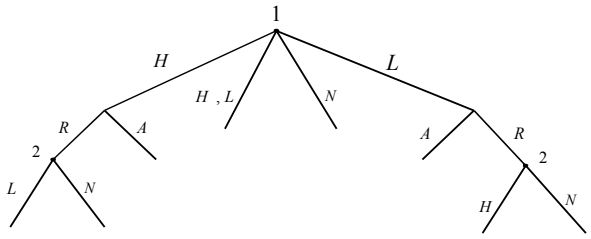

Figure 7: "Decision tree" of multiple submissions

The decision tree for an author is shown in figure 7, where action "H, L" represents submitting the paper to both journals and the other notations are the same as in figure 4. In period $t = 1$, the expected payoff of submitting a paper with quality q to both journals is as follows:

$$
\begin{aligned}
M_{H,L}(q) &= \pi_H(q)B_H - P_H + [1-\pi_H(q)]\pi_L(q)B_L - P_L \\
&= M_H(q) + [1-\pi_H(q)]\pi_L(q)B_L - P_L \\
&= M_H(q) + [1-\pi_H(q)]M_L(q) - \pi_H(q)P_L
\end{aligned} \tag{40}
$$

According to the analysis in section 3.1.2, we know there exist unique q_2 and q_3 such that $M_{H,L}(q_2) = M_H(q_2)$ and $M_{H,L}(q_3) = M_L(q_3)$, and it's also satisfied that $q_0 < q_3 < \hat{q}_H < q_2$. So the curve of $M_{H,L}(q)$ is shown in figure 8.

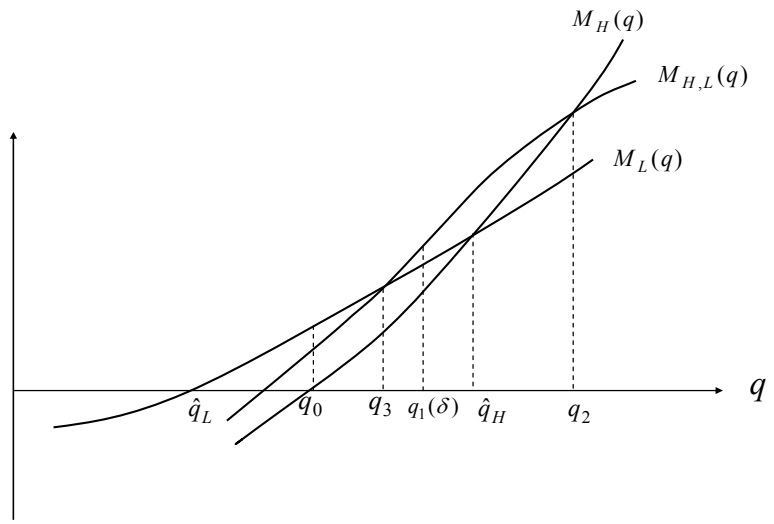

Figure 8: Expected payoff of submitting to journal H, L in period 2 and submitting to both journals in period 1

Obviously, the first period submission strategy for an author having a paper with quality q depends on the relative magnitude of $M_{1H}(q)$, $M_{H,L}(q)$ and $M_{1L}(q)$. By comparing the values of $M_{1H}(q)$, $M_{H,L}(q)$ and $M_{1L}(q)$, authors choose whether and where to submit the papers in the first period. We define $D_2(q) \equiv M_{1H}(q) - M_{H,L}(q)$ and $D_3(q) \equiv M_{1L}(q) - M_{H,L}(q)$.

Lemma 6: $M_{1L}(q)$ and $M_{H,L}(q)$ cross only once

Proof:

Since $D_3(q) \equiv M_{1L}(q) - M_{H,L}(q)$, then

$$\begin{aligned} D_3(q) &= M_{1L}(q) - M_{H,L}(q) \\ &= M_L + \delta(1-\pi_L)M_H - [M_H + (1-\pi_H)\pi_L B_L - P_L] \\ &= \pi_H \pi_L B_L - [1-\delta(1-\pi_L)]M_H \end{aligned} \tag{41}$$

$$\frac{dD_3(q)}{dq} = B_L(\pi_L'\pi_H + \pi_L\pi_H') - [1-\delta(1-\pi_L)]\pi_H' B_H - \delta\pi_L' M_H \tag{42}$$

Evaluating $\frac{dD_3(q)}{dq}$ at $D_3(q) = 0$ yields:

$$\frac{dD_3(q)}{dq} = B_L(\pi_L'\pi_H + \pi_L\pi_H') - [1-\delta(1-\pi_L)]\frac{\pi_H'}{\pi_H}\pi_H B_H - \delta\pi_L'\frac{\pi_H\pi_L}{1-\delta(1-\pi_L)}B_L \tag{43}$$

Simplifying (43), we have the following expression:

$$\begin{aligned} \frac{dD_3(q)}{dq} &= B_L\pi_H\pi_L\left(\frac{\pi_L'}{\pi_L} + \frac{\pi_H'}{\pi_H}\right) - [1-\delta(1-\pi_L)]\frac{\pi_H'}{\pi_H}\pi_H B_H - \delta\pi_L'\frac{\pi_H\pi_L}{1-\delta(1-\pi_L)}B_L \\ &= \pi_H B_L \pi_L\left[\left(\frac{\pi_L'}{\pi_L}\right)\left(\frac{1-\delta}{1-\delta(1-\pi_L)}\right) + \left(\frac{\pi_H'}{\pi_H}\right)\right] - [1-\delta(1-\pi_L)]\frac{\pi_H'}{\pi_H}\pi_H B_H \end{aligned} \tag{44}$$

By Assumption 3, we know that the hazard rate $h(x) \equiv \frac{g(x)}{1-G(x)}$ is increasing in x, thus $\frac{\pi_H'}{\pi_H} > \frac{\pi_L'}{\pi_L}$ since $s_H - q > s_L - q$. Thus we have the following expression:

$$
\begin{aligned}
\frac{dD_3(q)}{dq} &= \pi_H B_L \pi_L \left[\left(\frac{\pi'_L}{\pi_L} \right) \left(\frac{1-\delta}{1-\delta(1-\pi_L)} \right) + \left(\frac{\pi'_H}{\pi_H} \right) \right] - [1-\delta(1-\pi_L)] \frac{\pi'_H}{\pi_H} \pi_H B_H \\
&\le \pi_H B_L \pi_L \left[\left(\frac{\pi'_H}{\pi_H} \right) \left(\frac{1-\delta}{1-\delta(1-\pi_L)} \right) + \left(\frac{\pi'_H}{\pi_H} \right) \right] - [1-\delta(1-\pi_L)] \frac{\pi'_H}{\pi_H} \pi_H B_H \\
&= \left(\frac{\pi'_H}{\pi_H} \right) \pi_H \left\{ \frac{2(1-\delta)+\delta\pi_L}{1-\delta(1-\pi_L)} B_L \pi_L - [1-\delta(1-\pi_L)] B_H \right\} \\
&= \left(\frac{\pi'_H}{\pi_H} \right) \left(\frac{\pi_H}{1-\delta(1-\pi_L)} \right) \left\{ -\delta(\delta B_H - B_L)\pi_L^2 - 2(1-\delta)(\delta B_H - B_L)\pi_L - (1-\delta)^2 B_H \right\}
\end{aligned}
\tag{45}
$$

If $(\delta B_H - B_L) \ge 0$, the term in last bracket is negative and we have $\left. \frac{dD_3(q)}{dq} \right|_{D_3(q)=0} < 0$; If

$(\delta B_H - B_L) < 0$, since $0 \le \pi_L \le 1$, we have

$$
\begin{aligned}
&\left\{ -\delta(\delta B_H - B_L)\pi_L^2 - 2(1-\delta)(\delta B_H - B_L)\pi_L - (1-\delta)^2 B_H \right\} \\
&< \left\{ -\delta(\delta B_H - B_L) - 2(1-\delta)(\delta B_H - B_L) - (1-\delta)^2 B_H \right\} = (2-\delta) B_L - B_H
\end{aligned}
$$

From Assumption 6 or $B_H \ge 2B_L$, we know that $(2-\delta) B_L - B_H < 0$. Thus we always have

$\left. \frac{dD_3(q)}{dq} \right|_{D_3(q)=0} < 0 \ \ \forall \delta$. Therefore, the difference between $M_{1L}(q)$ and $M_{H,L}(q)$ is

monotonically decreasing in q. Combined

with $D_3(q_0) = \pi_H \pi_L B_L - [1-\delta(1-\pi_L)] M_H = \pi_H \pi_L B_L > 0$

and $\lim_{q \to +\infty} D_3(q) = B_L + P_H - B_H < 2B_L - B_H \le 0$, we know that $M_{1L}(q)$ and $M_{H,L}(q)$ cross

exactly once.

(Q.E.D)

Lemma 7: There exist either zero or two roots to the equation $D_2(q)=0$.

Proof:

Since $D_2(q)=M_{1H}(q)-M_{H,L}(q)$. Then

$$(46)\quad \begin{aligned} D_2(q) &= M_{1H}(q)-M_{H,L}(q) = P_L+\delta[1-\pi_H(q)][\pi_L(q)B_L-P_L]-[1-\pi_H(q)]\pi_L(q)B_L \\ &= \pi_L(q)P_L-(1-\delta)[1-\pi_H(q)]M_L \end{aligned}$$

Under Assumption 2, we know that $\lim_{q\to-\infty} D_2(q)=(1-\delta)P_L>0$ and $\lim_{q\to+\infty} D_2(q)=P_L>0$.

$$(47)\ \frac{dD_2(q)}{dq}=\delta P_L\pi'_H+(1-\delta)B_L[\pi_L\pi'_H-(1-\pi_H)\pi'_L]$$

$$(48)\ \frac{d^2D_2(q)}{dq^2}=\delta P_L\pi''_H+(1-\delta)B_L(\pi''_H\pi_L+\pi_H\pi''_L+2\pi'_H\pi'_L-\pi''_L)$$

Evaluating $\frac{d^2D_2(q)}{dq^2}$ at $\frac{dD_2(q)}{dq}=0$ yields:

(49)

$$\left.\frac{d^2D_2(q)}{dq^2}\right|_{(dD_2/dq)=0}=-\pi''_H(1-\delta)B_L\frac{\pi'_H\pi_L+\pi_H\pi'_L-\pi'_L}{\pi'_H}+(1-\delta)B_L(\pi''_H\pi_L+\pi_H\pi''_L+2\pi'_H\pi'_L-\pi''_L)$$

Simplifying (49), we have the following expression:

$$(50)\quad \begin{aligned} \left.\frac{d^2D_2(q)}{dq^2}\right|_{(dD_2/dq)=0} &= (1-\delta)B_L\frac{\pi_H\pi'_H\pi''_L+2\pi'_H\pi'_H\pi'_L-\pi'_H\pi''_L-\pi''_H\pi_H\pi'_L+\pi''_H\pi'_L}{\pi'_H} \\ &= (1-\delta)B_L\pi'_L\left[\pi_H\frac{\pi''_L}{\pi'_L}+2\pi'_H-\frac{\pi''_L}{\pi'_L}-\pi_H\frac{\pi''_H}{\pi'_H}+\frac{\pi''_H}{\pi'_H}\right] \\ &= (1-\delta)B_L\pi'_L\left[2\pi'_H+(1-\pi_H)(\frac{\pi''_H}{\pi'_H}-\frac{\pi''_L}{\pi'_L})\right] \end{aligned}$$

Define $y(\alpha) \equiv \ln\left[g(\alpha)\right]$, then $y'(\alpha) = \dfrac{g'(\alpha)}{g(\alpha)}$. By Assumption 3 or the log-concavity of the density function g, we know that $y''(\alpha) \le 0$ or $\dfrac{g'(\alpha)}{g(\alpha)}$ is decreasing (non-increasing) in α.

Then $\left[\dfrac{\pi_H''}{\pi_H'} - \dfrac{\pi_L''}{\pi_L'}\right] = \dfrac{g'(s_L - q)}{g(s_L - q)} - \dfrac{g'(s_H - q)}{g(s_H - q)} > 0$ since $s_H - q > s_L - q$. Because $\pi_H', \pi_L' > 0$, $\delta < 1$ and $(1 - \pi_H) > 0$, we know that $\left.\dfrac{d^2 D_2(q)}{dq^2}\right|_{(dD_2/dq)=0} > 0$. So whenever $\dfrac{dD_2}{dq} = 0$, $\dfrac{d^2 D_2}{dq^2} > 0$, which implies that given the continuity of $\dfrac{dD_2}{dq}$, there can be at most one extreme point, and that extreme point is a minimum. Therefore, $D_2(q)$ can cross the zero axis at most twice. Combined with $\lim_{q \to -\infty} D_2(q) = (1-\delta)P_L > 0$ and $\lim_{q \to +\infty} D_2(q) = P_L > 0$, we know that there are either zero or two values of q s.t. $D_2(q) = 0$.

(Q.E.D)

Lemma 8: Given the functions π_H and π_L, $\exists\ \hat{\delta}(\dfrac{B_L}{P_L}) < 1$, s.t. for $\delta > \hat{\delta}$, $M_{1H}(q) > M_{H,L}(q)\ \forall q$. This critical discount factor $\hat{\delta}$ is increasing in $\dfrac{B_L}{P_L}$.

Proof:

Since $D_2(q) = M_{1H}(q) - M_{H,L}(q)$**,** we know that

$$
\begin{aligned}
D_2(q) &= M_{1H}(q) - M_{H,L}(q) \\
&= P_L\left[1 - \delta(1-\pi_H)\right] - (1-\delta)(1-\pi_H)\pi_L B_L \\
&= P_L\left[1 - \delta(1-\pi_H)\right]\left\{1 - \left[\frac{(1-\delta)(1-\pi_H)\pi_L}{1-\delta(1-\pi_H)}\right]\frac{B_L}{P_L}\right\}
\end{aligned} \tag{51}
$$

Since both π_H and π_L are functions of q given other parameters, we can define

$V(q,\delta,\frac{B_L}{P_L}) \equiv \left\{1-\left[\frac{(1-\delta)(1-\pi_H)\pi_L}{1-\delta(1-\pi_H)}\right]\frac{B_L}{P_L}\right\}$. When $\delta=1$, we see that $V(q,1,\frac{B_L}{P_L})=1>0$. In addition, $\frac{\partial V}{\partial \delta}=\frac{B_L}{P_L}\frac{\pi_L\pi_H(1-\pi_H)}{\left[1-\delta(1-\pi_H)\right]^2}>0$. Since V is continuous in δ, there exists $\hat{\delta}<1$ s.t. $\forall \delta \geq \hat{\delta} \quad V \geq 0$. Also, $\frac{\partial V}{\partial (B_L/P_L)}=-\frac{(1-\delta)(1-\pi_H)\pi_L}{1-\delta(1-\pi_H)}<0$. Thus, by the implicit function theorem we know that:

$$(52)\quad \frac{d\hat{\delta}}{d(B_L/P_L)}=-\frac{\partial V/\partial(\frac{B_L}{P_L})}{\partial V/\partial\delta}>0$$

Therefore, given the functions π_H and π_L, $\exists\ \hat{\delta}(\frac{B_L}{P_L})$ s.t. for $\delta>\hat{\delta}$, $V>0\ \ \forall q$ or

$D_2(q)=M_{1H}(q)-M_{H,L}(q)>0\ \forall q$ since $P_L\left[1-\delta(1-\pi_H)\right]>0$

(Q.E.D)

From Lemma 8, we can derive the following Corollary 4.

Corollary 4: *When authors are patient enough, they will never simultaneously submit their papers to both journals.*

Proof:

By Lemma 8, we know that given parameter $\frac{B_L}{P_L}$, there is a critical discount factor $\hat{\delta}(\frac{B_L}{P_L})<1$ such that for $\delta>\hat{\delta}$, $M_{1H}(q)>M_{H,L}(q)\ \forall q$. So, when the discount factor δ is large enough,

multiple submission will be dominated by only submitting to the high quality journal. Thus, if authors are patient enough, they will never simultaneously submit their papers to both journals.

(Q.E.D)

For the rest of this section, we assume $\delta < \hat{\delta}(\frac{B_L}{P_L})$. From Lemma 7 and Lemma 8, there exists two roots $q^l(\delta)$ and $q_4(\delta)$ to the equation $D_2(q) = 0$, where $\hat{q}_L < q^l < q_4$, and $D_2(q) < 0$ for $q \in (q^l, q_4)$. Since $D_1(q_1, B_H) = M_{1H} - M_{1L} = 0$, we know that q_1 is a function of B_H given the other parameters. From previous analysis, we have $q_1 \in [\hat{q}_L, +\infty)$ for $B_H \in \left(B_H^l, B_H^u\right]$, where $B_H^u = \frac{P_H}{\pi_H(\hat{q}_L)}$ and $B_H^l = B_L + P_H - P_L$. By Proposition 3, we know that $D_1(q) = 0$ has a unique root q_1 and $D_1'(q_1) > 0$ or $M_{1H}(q)$ and $M_{1L}(q)$ have the single crossing point at q_1. Since $D_1(q) = \{1 - \delta[1 - \pi_L(q)]\}M_H(q) - \{1 - \delta[1 - \pi_H(q)]\}M_L(q)$, thus $\frac{\partial D_1}{\partial B_H} = \{1 - \delta(1 - \pi_L)\}\pi_H > 0$.

According to the implicit function theorem, we have

(53) $$\frac{dq_1}{dB_H} = -\frac{\partial D_1 / \partial B_H}{\partial D_1 / \partial q_1} < 0$$

Then we have the following Lemma 9.

Lemma 9: Given $\delta < \hat{\delta}(\frac{B_L}{P_L})$ and B_L, P_L, P_H, there exist $B_H', B_H'' \in \left(B_H^l, B_H^u\right]$ with $B_H' < B_H''$, where $q_1(B_H') = q_4$ and $q_1(B_H'') = q^l$. Hence:

1) $B_H \in \left(B_H^l, B_H'\right) \rightarrow q_1 > q_4$

2) $B_H \in [B_H', B_H''] \rightarrow q_1 \in \left[q^l, q_4\right]$

3) $B_H \in \left[B_H'', B_H^u \right] \rightarrow q_1 \in \left[\hat{q}_L, q^l \right]$

Proof:

For $\delta < \hat{\delta}(\frac{B_L}{P_L})$, there exist two roots $q^l(\delta)$ and $q_4(\delta)$ to $D_2(q) = 0$, where $q^l < q_4$. We know that $q_1 \in [\hat{q}_L, \infty)$ for $B_H \in \left(B_H^l, B_H^u \right]$ and $\hat{q}_L < q^l < q_4$. Since q_1 is a continuous function of B_H and $\frac{dq_1}{dB_H} < 0$, as B_H increases from B_H^l to B_H^u, there must exist $B_H', B_H'' \in \left(B_H^l, B_H^u \right]$, where $q_1(B_H') = q_4$, $q_1(B_H'') = q^l$ and $B_H' < B_H''$. Thus, we have $q_1 > q_4$ as $B_H \in \left(B_H^l, B_H' \right)$, $q_1 \in \left[q^l, q_4 \right]$ as $B_H \in [B_H', B_H'']$ and $q_1 \in \left[\hat{q}_L, q^l \right]$ as $B_H \in \left[B_H'', B_H^u \right]$.

(Q.E.D)

By Lemma 6, we know that $M_{1L}(q)$ and $M_{H,L}(q)$ have a single cross point. Suppose this single crossing point is q_5, thus $D_3(q_5) = 0$. Since $M_H(q_0) = 0$ and $D_3(q) = M_{1L}(q) - M_{H,L}(q) = \pi_H \pi_L B_L - [1 - \delta(1 - \pi_L)] M_H$, we have $D_3(q_0) = \pi_H \pi_L B_L > 0$. Because $D_3(q_5) = 0$ and $\left. \frac{dD_3(q)}{dq} \right|_{D_3(q)=0} < 0$, we know that $q_0 < q_5$. By Lemma 9, we have the following Proposition 4.

Proposition 4: If Assumptions 1- 6 hold and given $\frac{B_L}{P_L}$, assume the discount factor satisfies $\delta < \hat{\delta}(\frac{B_L}{P_L})$ so that there exist two roots q^l and q_4 to equation $D_2(q) = 0$, where $q^l < q_4$.

As the submission benefit in the high quality journal B_H changes, there exist three possible submission strategies.

1) For $B_H \in \left(B_H^l, B_H'\right)$, authors will have the following submission pattern:

- When $q \in \left[\hat{q}_L, q_0\right]$, submit to the low quality journal in period 1 and if rejected, don't submit in period 2.
- When $q \in \left[q_0, q_1\right]$, submit to the low quality journal in period 1 and if rejected, submit to the high quality journal in period 2.
- When $q \in \left[q_1, \infty\right]$, submit to the high quality journal in period 1 and if rejected, submit to the low quality journal in period 2.

2) For $B_H \in \left[B_H', B_H''\right]$, authors will have the following submission pattern:

- When $q \in \left[\hat{q}_L, q_0\right]$, submit to the low quality journal in period 1 and if rejected, don't submit in period 2.
- When $q \in \left[q_0, q_5\right]$, submit to the low quality journal in period 1 and if rejected, submit to the high quality journal in period 2.
- When $q \in \left[q_5, q_4\right]$, submit to both journals in period 1.
- When $q \in \left[q_4, \infty\right]$, submit to the high quality journal in period 1 and if rejected, submit to the low quality journal in period 2.

3) For $B_H \in \left[B_H'', B_H^u \right]$, authors will have the following submission pattern:

- When $q \in \left[\hat{q}_L, q_0 \right]$, submit to the low quality journal in period 1 and if rejected, don't submit in period 2.
- When $q \in \left[q_0, q_1 \right]$, submit to the low quality journal in period 1 and if rejected, submit to the high quality journal in period 2.
- When $q \in \left[q_1, q^l \right]$, submit to the high quality journal in period 1 and if rejected, submit to the low quality journal in period 2.
- When $q \in \left[q^l, q_4 \right]$, submit to both journals in period 1.
- When $q \in \left[q_4, \infty \right]$, submit to the high quality journal in period 1 and if rejected, submit to the low quality journal in period 2.

Proof:

Given parameters $\frac{B_L}{P_L}$, assume $\delta < \hat{\delta}(\frac{B_L}{P_L})$, we know that there exist two roots q^l and q_4 to equation $D_2(q) = 0$, where $q^l < q_4$. Thus, $D_2(q) < 0$ or $M_{1H}(q) - M_{H,L}(q) < 0$ when $q \in (q^l, q_4)$. According to Lemma 9, we will have the following three submission strategies:

1) If $B_H \in \left(B_H^l, B_H' \right)$ then $q_1 > q_4$, and at $q = q_1$ we have $M_{1H}(q_1) > M_{H,L}(q_1)$ or $D_3(q_1) > 0$. Because $D_3(q_5) = 0$ and $\left. \frac{dD_3(q)}{dq} \right|_{D_3(q)=0} < 0$, it must be true that $q_1 < q_5$.

Therefore, when $q \le q_1$, we have $D_1(q) \le 0$ and $D_3(q_1) > 0$, thus $M_{1L}(q) \ge M_{1H}(q)$ and $M_{1L}(q) > M_{H,L}(q)$. So submitting to the low quality journal in period 1 is the dominant strategy. When $q > q_1$, we have $D_1(q) > 0$ and $D_2(q) > 0$, thus $M_{1H}(q) > M_{1L}(q)$ and $M_{1H}(q) > M_{H,L}(q)$, and thus submitting to the high quality journal is the dominant strategy. According to previous analysis, we know that $\hat{q}_L < q_0 < q_1$. Thus, if $q \in [\hat{q}_L, q_0]$, since $M_H(q) \le 0$ there is no submission in period 2 if rejected in period 1; if $q \in [q_0, q_1]$, the paper will be resubmitted to the high quality journal in period 2 if rejected in period 1. Therefore, authors have the first submission pattern identified in the proposition.

2) If $B_H \in [B_H', B_H'']$ then $q_1 \in [q^l, q_4]$, and thus at $q = q_1$,

$M_{1L}(q_1) = M_{1H}(q_1) < M_{H,L}(q_1)$, implying $D_3(q_1) = M_{1L}(q_1) - M_{H,L}(q_1) < 0$. Since $D_3(q_5) = 0$ and $\left.\frac{dD_3(q)}{dq}\right|_{D_3(q)=0} < 0$, it must be that $q_5 < q_1$. Further, at q^l, $M_{H,L}(q^l) = M_{1H}(q^l) \le M_{1L}(q^l)$, where the last equality holds because $q^l \le q_1$. Thus, it must be true that $q_5 > q^l$ and hence: $q^l < q_5 < q_1 < q_4$ for $B_H \in [B_H', B_H'']$. Therefore:

- When $q \le q_5$, we have $D_1(q) < 0$ and $D_3(q) \ge 0$, and thus $M_{1L}(q) > M_{1H}(q)$ and $M_{1L}(q) \ge M_{H,L}(q)$. Since $\hat{q}_L < q_0 < q_5$, so when $q \in [\hat{q}_L, q_0]$, authors will submit the paper to only the low quality journal in the first period and will not resubmit the paper in the second period if rejected in the first period; when $q \in [q_0, q_5]$, authors will submit the

paper to only the low quality journal in the first period and resubmit to the high quality journal in the second period if rejected in the first period.

- When $q_5 < q < q_4$, we have $D_3(q) < 0$ and $D_2(q) < 0$, thus $M_{1L}(q) < M_{H,L}(q)$ and $M_{1H}(q) < M_{H,L}(q)$. Thus, authors will choose to simultaneously submit their papers to both journals in the first period.

- Finally, when $q \geq q_4 > q_1$, we have $D_1(q) > 0$ and $D_2(q) \geq 0$, thus $M_{1H}(q) > M_{1L}(q)$ and $M_{1H}(q) \geq M_{H,L}(q)$. So authors will submit the paper to only the high quality journal in the first period and resubmit to the low quality journal in the second period if rejected in the first period.

3) If $B_H \in \left[B_H'', B_H^u \right]$ then $q_1 \in \left[q_0, q^l \right]$, where $q_0 > \hat{q}_L$ and thus:

- When $q \leq q_1$, we have $D_1(q) \leq 0$ and $D_2(q) > 0$, thus $M_{1L}(q) \geq M_{1H}(q) > M_{H,L}(q)$. Since $\hat{q}_L < q_0 < q_1$, when $q \in \left[\hat{q}_L, q_0 \right]$, the optimal strategy is to submitting to the low quality journal in period 1 and if rejected, don't submit to the high quality journal in period 2; when $q \in \left[q_0, q_1 \right]$, submitting to only the low quality journal in period 1 and if rejected, re-submitting to the high quality journal in period 2 is the optimal strategy.

- When $q_1 < q \leq q^l$, we have $D_1(q) > 0$ and $D_2(q) > 0$, thus $M_{1H}(q) > M_{1L}(q)$ and $M_{1H}(q) \geq M_{H,L}(q)$. And thus submitting to only the high quality journal in period 1 and if rejected, re-submitting to the low quality journal in period 2 is the optimal strategy.

- When $q^l < q < q_4$, we have $D_1(q) > 0$ and $D_2(q) < 0$, thus $M_{H,L}(q) > M_{1H}(q) > M_{1L}(q)$ and submitting to both journals in the first period is the dominant strategy.

- Finally, when $q \geq q_4$, we have $D_1(q) > 0$ and $D_2(q) > 0$, thus $M_{1H}(q) > M_{1L}(q)$ and $M_{1H}(q) \geq M_{H,L}(q)$. Thus, submitting to only the high quality journal in period 1 and if rejected, re-submitting to the low quality journal in period 2 is the optimal strategy.

(Q.E.D)

From the above analysis, we know that given the ratio of the publication benefit to submission fee in the low quality journal, if authors' are patient enough they will never submit their papers to both journals simultaneously. Otherwise, whether the multiple-submission may occur in their optimal submission strategy depends on the magnitude of the publication benefit in the high quality journal. When the publication benefit in the high quality journal is small enough, authors will never include multiple-submission in their strategy. When the publication benefit in the high quality journal is relatively large, multiple-submission is possible and an author's strategy depends on the paper's quality. As the paper's quality increases, the submission decision changes from submitting to only the low quality journal, to submitting to both journals then to submitting to only the high quality journal. When the publication benefit in the high quality journal is large enough, an author's submission decision changes from submitting to only the low quality journal, to submitting to only the high quality journal, to submitting to both journals, then to submitting to only the high quality journal as the paper's quality increases.

To investigate the expected per-period number of submissions and average quality of accepted papers in both journals, we assume that $B_H \in [B'_H, B''_H]$. Thus, authors will have the second submission pattern as discussed in Proposition 4. The submission strategy in this case can be illustrated in table 3.

Table 3: submission strategy in "multiple submissions"

	$t=1$	$t=2$
$q \in [q_4, +\infty)$	H	$\xrightarrow{if\ \ rejected} L$
$q \in [q_5, q_4)$	H, L	
$q \in [q_0, q_5)$	L	$\xrightarrow{if\ \ rejected} H$
$q \in [\hat{q}_L, q_0)$	L	$\xrightarrow{if\ \ rejected} N$
$q \in (-\infty, \hat{q}_L)$	N	N

According to table 3, it's straightforward to see that the per-period expected number of submissions to journal H is as follows:

$$\begin{aligned} N_H^{MS} &= N[1-F(q_5)] + N[F(q_5)-F(q_0)]Prob(q+\alpha < s_L \mid q_0 \le q < q_5) \\ &= N[1-F(q_5)] + N[\int_{q_0}^{q_5} f(q)G(s_L-q)dq] \end{aligned} \tag{54}$$

The average quality of the papers accepted for publication in journal H is:

$$(55)\quad Q_H^{MS} = \frac{\int_{q_5}^{+\infty} qf(q)[1-G(s_H-q)]dq + \int_{q_0}^{q_5} qf(q)G(s_L-q)[1-G(s_H-q)]dq}{\int_{q_5}^{+\infty} f(q)[1-G(s_H-q)]dq + \int_{q_0}^{q_5} f(q)G(s_L-q)[1-G(s_H-q)]dq}$$

And the expected per-period number of submissions to journal L is as follows:

$$(56)\quad \begin{aligned} N_L^{MS} &= N[F(q_4)-F(\hat{q}_L)] + N[1-F(q_4)]Prob(q+\alpha < s_H \mid q \geq q_4) \\ &= N[F(q_4)-F(\hat{q}_L)] + N[\int_{q_4}^{+\infty} f(q)G(s_H-q)dq] \end{aligned}$$

The average quality of the paper accepted for publication in journal L is:

$$(57)\quad Q_L^{MS} = \frac{\int_{\hat{q}_L}^{q_4} qf(q)[1-G(s_L-q)]dq + \int_{q_4}^{+\infty} qf(q)G(s_H-q)[1-G(s_L-q)]dq}{\int_{\hat{q}_L}^{q_4} f(q)[1-G(s_L-q)]dq + \int_{q_4}^{+\infty} f(q)G(s_H-q)[1-G(s_L-q)]dq}$$

Compared to the "single submission" case analyzed in section 4.1, we have the following relations:

$$(58)\quad \begin{aligned} N_H^{MS} - N_H = N[F(q_1)-F(q_5)] + \{&N[F(q_5)-F(q_0)]Prob(\alpha+q<s_L \mid q_0 \leq q < q_5) \\ &- N[F(q_1)-F(q_0)]Prob(\alpha+q<s_L \mid q_0 \leq q < q_1)\} \end{aligned}$$

$$(59)\quad \begin{aligned} N_L^{MS} - N_L = N[F(q_4)-F(q_1)] + \\ \{N[1-F(q_4)]Prob(q+\alpha<s_H \mid q \geq q_4) - N[1-F(q_1)]Prob(q+\alpha<s_H \mid q \geq q_1)\} \end{aligned}$$

Therefore, we know the following:

$$N_H^{MS} - N_H = N[F(q_1) - F(q_5)] + N\{\int_{q_0}^{q_5} f(q)G(s_L - q)dq - \int_{q_0}^{q_1} f(q)G(s_L - q)dq\}$$
$$= N[F(q_1) - F(q_5)] - N\{\int_{q_5}^{q_1} f(q)G(s_L - q)dq\} \quad (60)$$

Since $0 < G(s_L - q) < 1$ and $q_1 > q_5$, so $\int_{q_5}^{q_1} f(q)G(s_L - q)dq < \int_{q_5}^{q_1} f(q)dq = F(q_1) - F(q_5)$

Thus, $N_H^{MS} - N_H > N[F(q_1) - F(q_5)] - N[F(q_1) - F(q_5)] = 0$

$$N_L^{MS} - N_L = N[F(q_4) - F(q_1)] + N\{\int_{q_4}^{+\infty} f(q)G(s_H - q)dq - \int_{q_1}^{+\infty} f(q)G(s_H - q)dq\}$$
$$= N[F(q_4) - F(q_1)] - N\int_{q_1}^{q_4} f(q)G(s_H - q)dq \quad (61)$$

Since $0 < G(s_H - q) < 1$ and $q_4 > q_1$, so $\int_{q_1}^{q_4} f(q)G(s_H - q)dq < \int_{q_1}^{q_4} f(q)dq = F(q_4) - F(q_1)$

Thus,

$N_L^{MS} - N_L > N[F(q_4) - F(q_1)] - N[F(q_4) - F(q_1)] = 0$

So the per period number of submission in both journals under multiple-submission will be higher than that under single submission. Both the sign of $(Q_H^{MS} - Q_H)$ and $(Q_L^{MS} - Q_L)$ are ambiguous. So, we cannot say that a multiple-submission policy would deteriorate the average quality of accepted papers. In order to illustrate these, we assume that each author produces a paper with the random quality $q \sim N[1,1]$, and we calibrate the model to get some numerical simulation results which are reported in next chapter. So far, we have illustrated that the expected per-period number of submissions in both journals under "multiple submissions" are higher than those under "single submission" and the average quality of accepted papers in both journals when

multiple submissions were allowed is not necessarily lower than that in the case of single submission. The results are illustrated in the following corollary 5.

Corollary 5:

Since the average quality of accepted papers in both journals under "multiple-submission" can be lower than that under "single submission", a multiple-submission policy may not necessarily reduce the average quality of published papers.

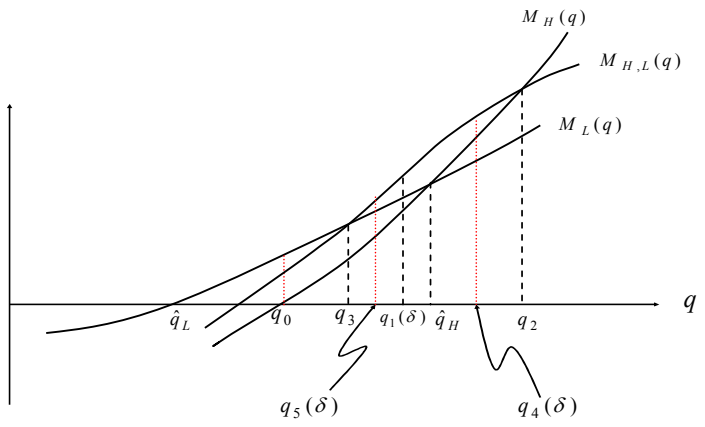

Figure 9: Some quality thresholds in the submission strategy

Figure 9 shows the quality partitions which determine the author's optimal submission strategy. From figure 9, we know that $q_4(\delta)$ is determined by $M_{H,L}(q_4) = M_{1H}(q_4)$, and $q_4(\delta) \to q_2$ as $\delta \to 0$. In particular, there is $M_{H,L}(q_4) = M_{1H}(q_4) = M_H(q_4)$ when $\delta = 0$, so we have $q_4 = q_2$.

Also, $q_5(\delta)$ is determined by $M_{H,L}(q_5) = M_{1L}(q_5)$, and $q_5(\delta) \to q_3$ as $\delta \to 0$. When $\delta = 0$, we know $M_{H,L}(q_5) = M_{1L}(q_5) = M_L(q_5)$, so $q_5 = q_3$.

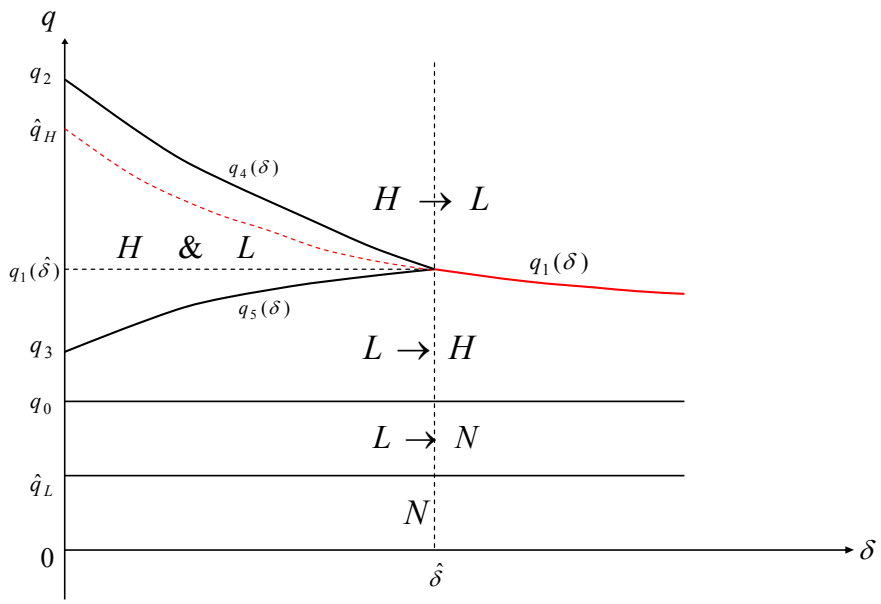

Figure 10: Submission strategy in "multiple submission" as δ changes

Figure 10 illustrates how the quality thresholds which determine an author's optimal submission strategy change as the discount factor changes. As shown in figure 10, when the discount factor δ decreases, the number of papers that will be simultaneously submitted to both journals in the first period increases. In other words, as the authors become less patient, they are more likely to submit their new papers to both journals so as to get a higher probability of being accepted for publication in current period instead of waiting until next period.

Corollary 5 illustrates the author's optimal submission strategy when $\delta < \hat{\delta}$. If $\delta \geq \hat{\delta}$, authors will never choose to simultaneously submit their papers to both journals. It's straightforward to see from figure 10 that as δ increases, q_4 declines and q_5 rises and the area for multiple submissions shrink. The two points q_4 and q_5 will converge to q_1 when δ reaches $\hat{\delta}$. After $\delta \geq \hat{\delta}$, there is no area for multiple submissions and the author's submission strategy is exactly the same as the "single submission" case analyzed in section 3.1. Lemma 8 implies that if the authors are sufficiently patient, the "multiple submissions" will always be dominated by "single submission". In other words, the authors would rather resubmit their papers in the second period than simultaneously submit the papers to both journals in the first period. Also, as the authors becomes more patient, there will be more submissions to the high quality journal in the first period.

CHAPTER 4. NUMERICAL SIMULATIONS

In this section, we will do some comparative static analysis to show how the quality thresholds which determine authors' submission strategies change as the parameters vary. Then, we perform numerical simulations to compare the expected per-period number of submissions and the average quality of accepted papers in both journals under the single and multiple submission policy regimes.

4.1 Simulation for the case of single submission

According to the analysis in section 3.1, we know that $\hat{q}_H$ is determined by

$M_H(\hat{q}_H) = M_L(\hat{q}_H)$ or $B_H[1-G(s_H-\hat{q}_H)]-P_H = B_L[1-G(s_L-\hat{q}_H)]-P_L$

Assuming $\alpha \sim N[0,\sigma^2]$, $\hat{q}_H$ is determined by

(62) $B_H[1-\Phi(\frac{s_H-\hat{q}_H}{\sigma})]-P_H = B_L[1-\Phi(\frac{s_L-\hat{q}_H}{\sigma})]-P_L$

Differentiating (62) with respect to $\hat{q}_H$ and σ we get:

(63) $$\frac{\partial \hat{q}_H}{\partial \sigma} = -\frac{1}{\sigma}\frac{B_H\phi(\frac{s_H-\hat{q}_H}{\sigma})(s_H-\hat{q}_H)-B_L\phi(\frac{s_L-\hat{q}_H}{\sigma})(s_L-\hat{q}_H)}{B_H\phi(\frac{s_H-\hat{q}_H}{\sigma})-B_L\phi(\frac{s_L-\hat{q}_H}{\sigma})}$$

According to Assumption 3, we know that the hazard rate is monotonically increasing or

$$\frac{\frac{\phi(\frac{s_H-\hat{q}_H}{\sigma})}{\sigma}}{1-\Phi(\frac{s_H-\hat{q}_H}{\sigma})} > \frac{\frac{\phi(\frac{s_L-\hat{q}_H}{\sigma})}{\sigma}}{1-\Phi(\frac{s_L-\hat{q}_H}{\sigma})}$$

q_0 is determined by $M_H(q_0)=0$ or $B_H[1-G(s_H-q_0)]-P_H=0$ or

(64) $B_H[1-\Phi(\frac{s_H-q_0}{\sigma})]-P_H=0$

Differentiating (64) with respect to q_0 and σ we get:

(65) $\frac{\partial q_0}{\partial \sigma}=-\frac{1}{\sigma}(s_H-q_0)$

Because $B_H[1-\Phi(\frac{s_H-q_0}{\sigma})]-P_H=0\Rightarrow\Phi(\frac{s_H-q_0}{\sigma})=1-\frac{P_H}{B_H}$

If $B_H\geq 2P_H$, $\Phi(\frac{s_H-q_0}{\sigma})=1-\frac{P_H}{B_H}\geq\frac{1}{2}\Rightarrow s_H-q_0\geq 0$, thus $\frac{\partial q_0}{\partial \sigma}=-\frac{1}{\sigma}(s_H-q_0)\leq 0$

If $B_H<2P_H$, $\Phi(\frac{s_H-q_0}{\sigma})=1-\frac{P_H}{B_H}<\frac{1}{2}\Rightarrow s_H-q_0<0$, thus $\frac{\partial q_0}{\partial \sigma}=-\frac{1}{\sigma}(s_H-q_0)>0$

$\hat{q}_L$ is determined by $M_L(\hat{q}_L)=0$ or $B_L[1-G(s_L-\hat{q}_L)]-P_L=0$ or

(66) $B_L[1-\Phi(\frac{s_L-\hat{q}_L}{\sigma})]-P_L=0$

Differentiating (66) with respect to $\hat{q}_L$ and σ we get:

(67) $\frac{\partial \hat{q}_L}{\partial \sigma}=-\frac{1}{\sigma}(s_L-\hat{q}_L)$

Because $B_L[1-\Phi(\frac{s_L-\hat{q}_L}{\sigma})]-P_L=0=0\Rightarrow\Phi(\frac{s_L-\hat{q}_L}{\sigma})=1-\frac{P_L}{B_L}$

If $B_L\geq 2P_L$, $\Phi(\frac{s_L-\hat{q}_L}{\sigma})=1-\frac{P_L}{B_L}\geq\frac{1}{2}\Rightarrow s_L-\hat{q}_L\geq 0$, thus $\frac{\partial \hat{q}_L}{\partial \sigma}=-\frac{1}{\sigma}(s_L-\hat{q}_L)\leq 0$

If $B_L<2P_L$, $\Phi(\frac{s_L-\hat{q}_L}{\sigma})=1-\frac{P_L}{B_L}<\frac{1}{2}\Rightarrow s_L-\hat{q}_L<0$, thus $\frac{\partial \hat{q}_L}{\partial \sigma}=-\frac{1}{\sigma}(s_L-\hat{q}_L)>0$

We can use numerical simulation to see how quality thresholds change with respect to referee's quality assessment error σ. Choosing parameters as $B_H=20, B_L=5, S_H=3, S_L=1, P_H=2, P_L=1$

and $\delta = 0.85$, which satisfy the Assumptions 1-6, we did the simulation and the following figure 11 show how the quality thresholds change as σ varies.

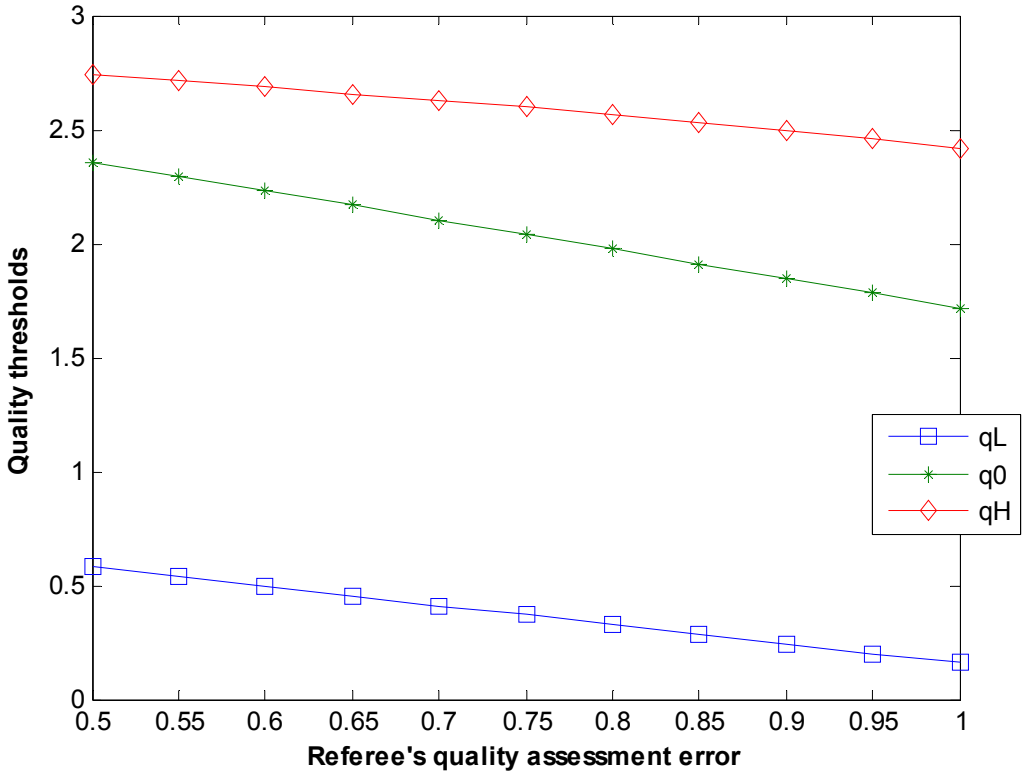

Figure 11: Quality thresholds in single submission and single period case

From the simulation results as shown in figure 11, we can see that q_L, q_0 and $\hat{q}_H$ decrease as the variance of referee's quality assessment error increases.

When referees have quality assessment errors, an author's quality threshold of submission wouldn't be the same as the journal's quality standard. But if referees have perfect assessment of

papers' quality, any paper with quality lower than journal's standard will be rejected, thus an author's quality threshold of submission will equal to the journal's quality standard since we assume an author has perfect information about the quality of his paper. As the variance of referee's quality assessment error decreases to a small number, e.g. $\sigma = 0.01$, we have the quality thresholds: $q_L = 0.9916$, $q_0 = 2.9872$, $q_H = 2.9948$. Therefore, as referee's quality assessment is more accurate, the quality threshold of submitting to low quality journal $q_L = 0.9916$ is very close to its quality standard $s_L = 1$ and the quality threshold of submitting to the high quality journal is very close to its quality standard $s_H = 3$. Thus, the quality threshold of submitting to both journals converges to their standards as the variance of referees' quality assessment error shrinks to zero.

We can also do simulation to reproduce figure 6 to show how quality thresholds, which determine author's submission strategy in both single and multiple submission, change as discount factor δ varies. Choosing parameters as $B_H = 20, B_L = 5, s_H = 3, s_L = 1, P_H = 2, P_L = 1$ and $\sigma = 1$, as discount factor δ changes from 0 to 1, with 0.01 increase in each step, we did simulation to calculate and plot the value of quality thresholds q_L, q_0 and q_1, where q_1 is the quality threshold of submitting to journal H and L at first period in the two-period and single submission case. Corollary 3 states that the quality threshold for a paper to be submitted to the high quality journal in the first period decreases as the author's discount factor increases. The following figure 12 shows that q_1 decreases as δ increases, which is consistent with the analysis in Corollary 3 and figure 6.

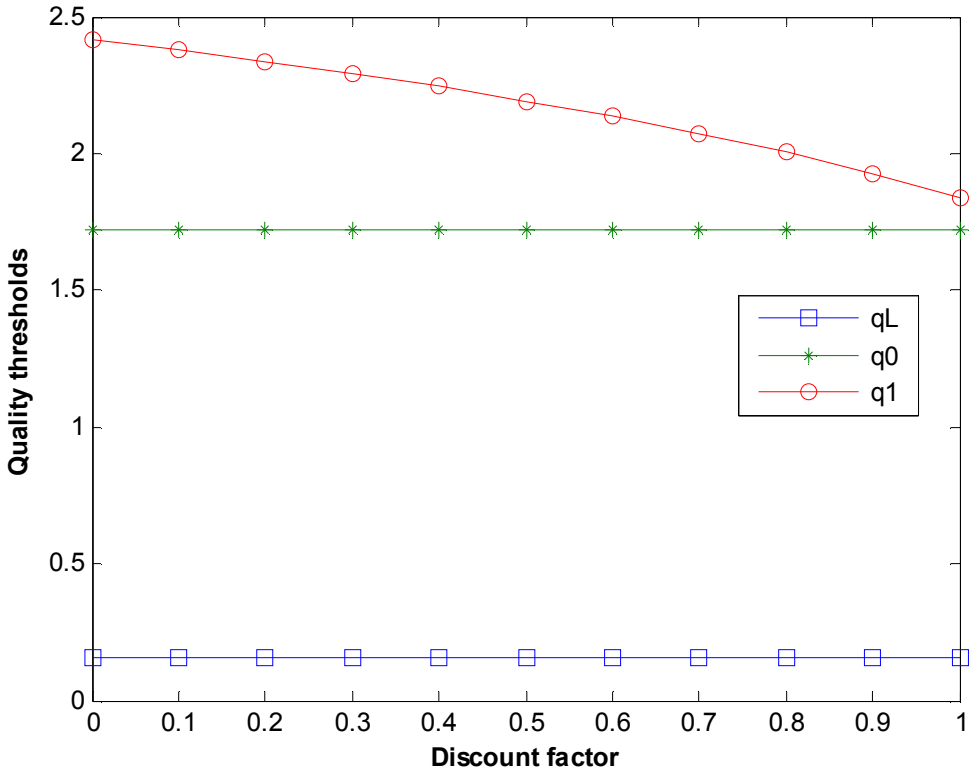

Figure 12: Quality thresholds as discount factor changes in single submission

Choosing the parameters to be $B_H = 20, B_L = 5, s_H = 3, s_L = 1, P_H = 2, P_L = 1$, we can also perform simulations to show how the author's quality threshold varies as both the variance of the referee's quality assessment error and the author's discount factor change in the two-period and single submission case. As the authors' discount factor changes from 0 to 1 and the variance of referee's quality assessment error changes from 0.5 to 1 with 0.1 in each step, we did numerical simulation on q_1, which is the quality threshold between submitting to journal H and journal L in first period. The simulation result is shown in the following figure 13-1.

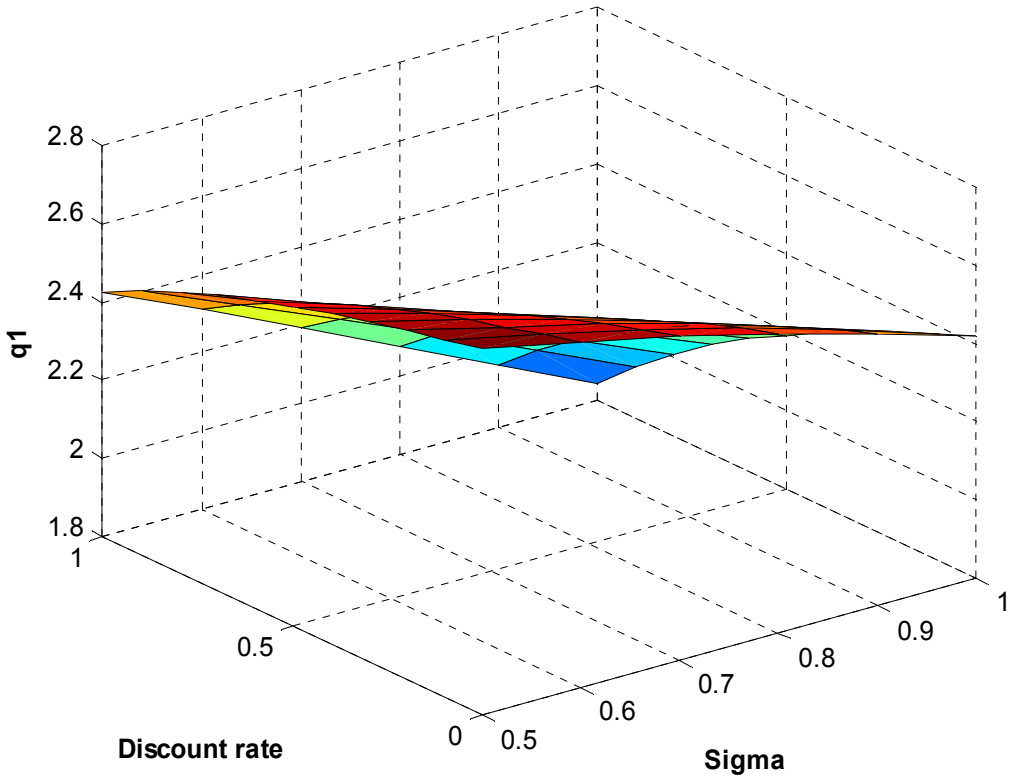

Figure 13-1: q1 is below high quality journal's standard

From the above figure, we know that q_1 is less than the high quality journal's standard $s_H = 3$ given the chosen parameters. In this case, as the variance of the referee's quality assessment error decreases q_1 increases and as the author's discount factor decreases q_1 increases. In other words, as authors become less patient and referee's quality assessment gets more accurate, the quality threshold of submitting to high quality journal increases, which implies that only those papers with relatively high quality will be submitted to the high quality journal when authors are not very patient and referees have accurate quality assessment. When discount factor $\delta = 0$ and variance of quality assessment error $\sigma = 0.5$, q_1 reaches the highest point 2.7377.

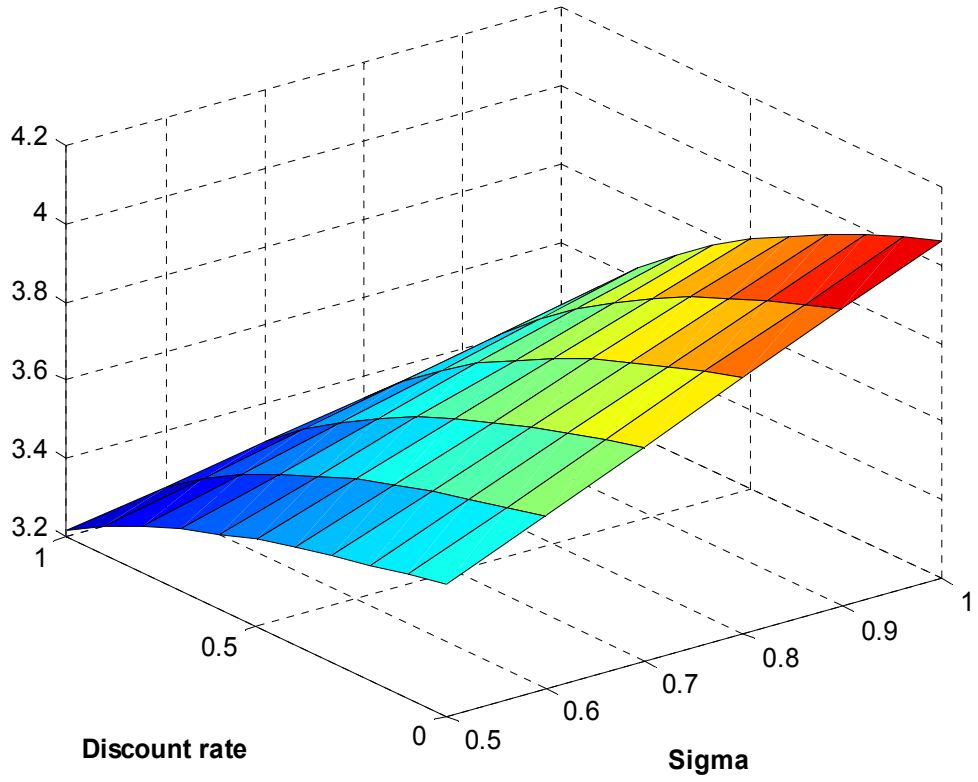

Figure 13-2: q1 is above the high quality journal's standard

When the high quality journal's publication benefit is large, some papers with quality below the high journal's standard will be submitted to journal H . But if the publication benefit B_H is relatively low, the high quality journal will not be so attractive to those authors with low quality papers and we expect q_1 to be greater than s_H . If we decrease the high quality journal's publication benefit from $B_H = 20$ to $B_H = 7$ and keep the other parameters unchanged, we can perform another simulation to show how the author's quality threshold varies as both the variance of the referee's quality assessment error and the author's discount factor change in the two-period and single submission case. The simulation result is shown in figure 13-2. From the above figure, we know that q_1 is now above the high quality journal's standard $s_H = 3$ in this case. And q_1

increases as the variance of the referee's quality assessment error increases. We still have that q_1 increases as the author's discount factor decreases. In other words, as authors become less patient and referee's quality assessment gets less accurate, the quality threshold of submitting to high quality journal increases, which implies that more papers will be submitted to the high quality journal when authors are not very patient and referees have less accurate quality assessment. When discount factor $\delta = 0$ and variance of quality assessment error $\sigma = 1$, q_1 reaches the highest point 4.0641.

4.2 Simulation for the case of multiple-submission

From the analysis in section 3.2, we know that given the ratio of publication benefit to submission fee in the low quality journal $\frac{B_L}{P_L}$, if authors' are patient enough such that $\delta > \hat{\delta}(\frac{B_L}{P_L})$, they will never submit their papers to both journals simultaneously. Otherwise, if $\delta < \hat{\delta}(\frac{B_L}{P_L})$, then whether the multiple-submission is possible in their submission strategy depends on the magnitude of the publication benefit in the high quality journal B_H. When the publication benefit in high quality journal is small enough, authors will never include multiple-submission in their strategy. When the publication benefit in the high quality journal is relatively large, multiple-submission is possible and the author's first period decision changes from submitting to only the low quality journal, to submitting to both journals, then to submitting to only the high quality journal as the paper's quality increases.

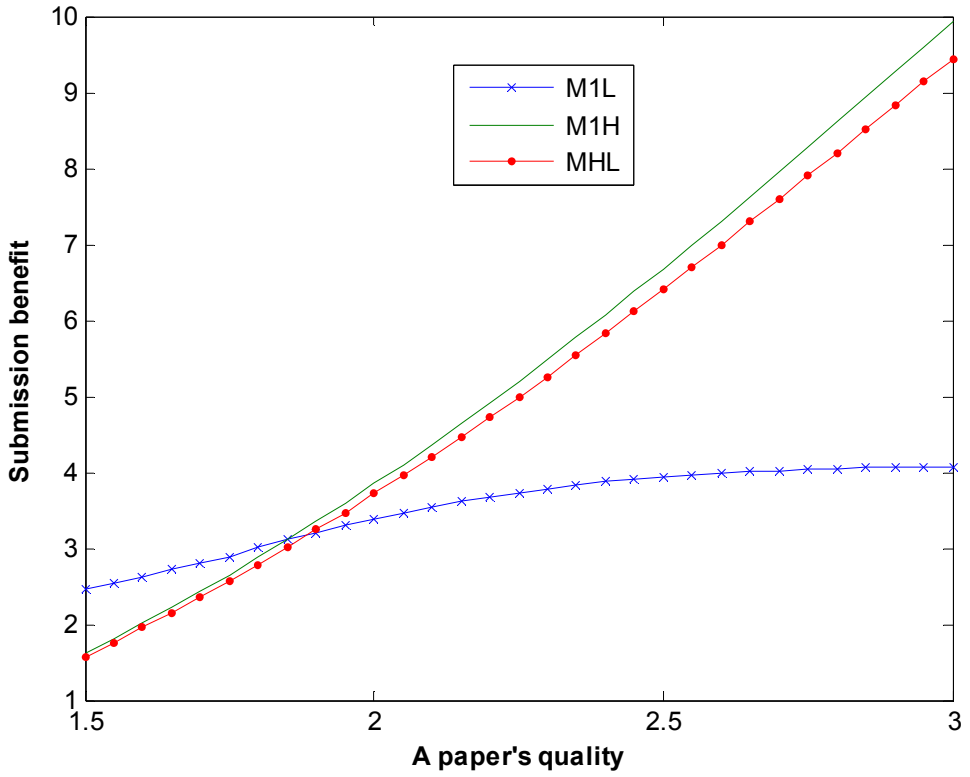

Figure 14: Expected submission benefits when authors are patient enough

Let parameters take values $B_H = 20, B_L = 5, s_H = 3, s_L = 1, P_H = 2, P_L = 1$, $\sigma = 1$. As a paper's quality q changes, we can do a numerical simulation to plot the values of publication benefits $M_{1H}(q)$, $M_{1L}(q)$ and $M_{H,L}(q)$ to show how these curves intersect with each other, which could straightforwardly show the author's submission strategy. Suppose authors are patient enough by choosing a very large discount factor $\delta = 0.99$, the simulation result in following figure 14 shows that when q has a low value, $M_{1L}(q)$ is larger than $M_{1H}(q)$ and $M_{H,L}(q)$, which means that submitting to the low quality journal in first stage is the dominant strategy; As q increases, $M_{1H}(q)$ is larger than both $M_{1L}(q)$ and $M_{H,L}(q)$, and submitting to the high quality journal in

the first period is the dominant strategy. Thus, when authors are patient enough they will never choose multiple-submission. According to the simulation result, $M_{1L}(q)$ and $M_{1H}(q)$ intersects at $q = 1.85$, and $M_{1L}(q) < 0$ when $q < 0.155$. Then the papers with quality $q \in (0.155, 1.85)$ will be submitted to the low quality journal and the papers with quality higher than 1.85 will be submitted to the high quality journal in the first period.

Next, we choose $\delta = 0.85$ so multiple-submission is possible and investigate how an author's submission strategy changes as the publication benefit in high quality journal B_H changes. First, we choose a small publication benefit level in high quality journal $B_H = 10$. The simulation result in following figure 15 shows that at first $M_{1L}(q)$ is larger than $M_{1H}(q)$ and $M_{H,L}(q)$, thus submitting to only the low quality journal in first period is the dominant strategy. Then $M_{1H}(q)$ is larger than $M_{1L}(q)$ and $M_{H,L}(q)$ as q increases, thus submitting to only the high quality journal is the dominant strategy. So submitting to both journals is always dominated by single submission. Thus, when the publication benefit in high quality journal is relatively small, authors will never choose multiple-submission. The simulation result shows that $M_{1L}(q)$ and $M_{1H}(q)$ intersects at $q = 2.69$, and $M_{1L}(q) < 0$ when $q < 0.15$. Then the papers with quality $q \in (0.15, 2.69)$ will be submitted to the low quality journal and the papers with quality higher than 2.69 will be submitted to the high quality journal in the first period.

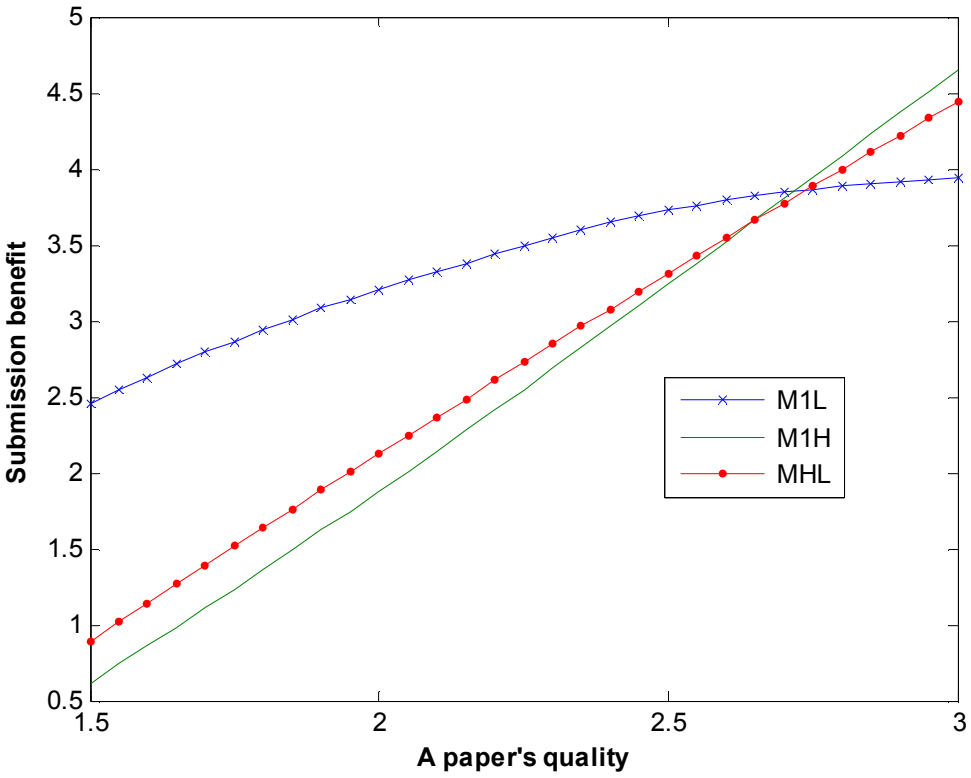

Figure 15: Expected submission benefits when B_H is small

Then, we choose a relative large value for the publication benefit in high quality journal $B_H = 20$ and keep the other parameters unchanged $B_L = 5, s_H = 3, s_L = 1, P_H = 2, P_L = 1, \sigma = 1, \delta = 0.85$ .The simulation result in following figure 16 shows that as q increases from a low value, $M_{1L}(q)$ is larger than $M_{1H}(q)$ and $M_{H,L}(q)$, which means that submission in the low quality journal in first stage is the dominant strategy; As q increases to a middle value, $M_{H,L}(q)$ is larger than $M_{1L}(q)$ and $M_{1H}(q)$, then submitting to both journals is the optimal strategy; As q has a high value, $M_{1H}(q)$ is larger than both $M_{1L}(q)$ and $M_{H,L}(q)$, and submitting to only high quality journal is the dominant strategy. Thus, when the publication benefit in high quality journal

is relatively large, authors will incorporate multiple-submission in their submission strategy. The simulation result shows that $M_{1L}(q)$ and $M_{H,L}(q)$ intersects at $q=1.88$, $M_{1H}(q)$ and $M_{H,L}(q)$ intersects at $q=2.64$, and $M_{1L}(q)<0$ when $q<0.15$. Then the papers with quality $q\in(0.15,1.88)$ will be submitted to the low quality journal, the papers with quality $q\in(1.88,2.64)$ will be submitted to both journals and the papers with quality higher than 2.64 will be submitted to the high quality journal in the first period.

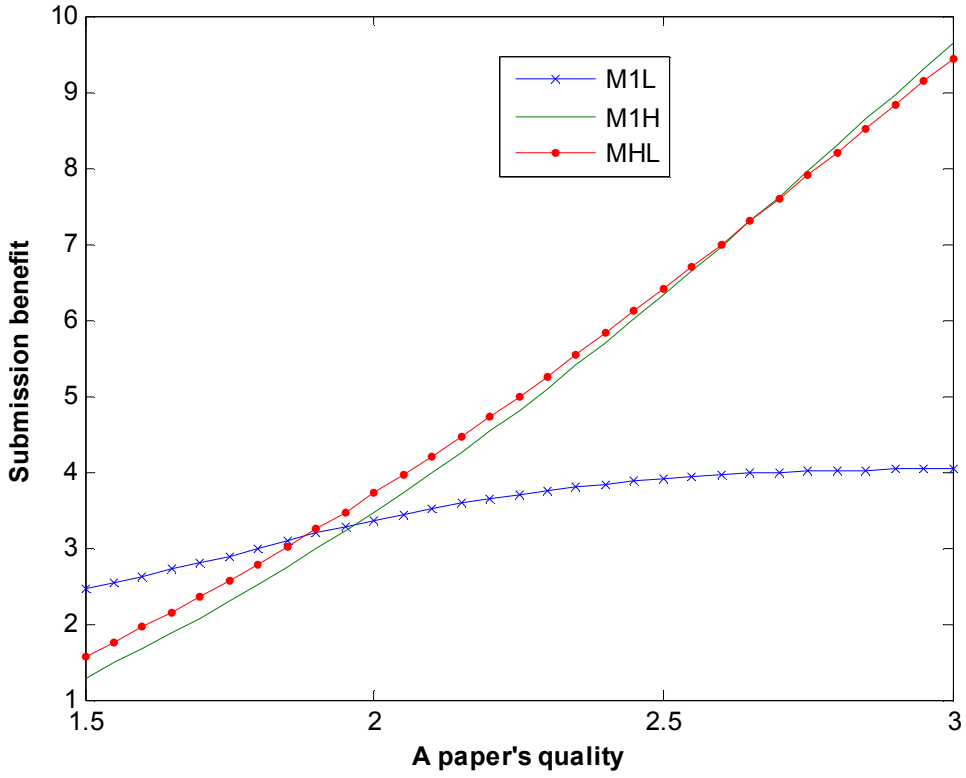

Figure 16: Expected submission benefits when B_H is relatively large

Last, choose parameters $B_L = 5, s_H = 3, s_L = 1, P_H = 2, P_L = 1, \sigma = 1, \delta = 0.95$. We perform a simulation to investigate how the quality thresholds q_1 change as the publication benefit in the high quality journal changes, which could show the possible submission strategies we stated in proposition 4. The simulation result shows that $\hat{q}_L = 0.1584$, $q^l = 0.2655$, $q_4 = 1.2139$, $B_H'' = 645$ and $B_H^u = 891$. From figure 17, we know q_1 decreases as B_H increases and approaches $\hat{q}_L$ when B_H approaches the upper bound $B_H^u = 891$. When $B_H \in [B_H'', B_H^u]$, $q_1 \in [\hat{q}_L, q^l]$ and authors have the third submission strategy as we stated in proposition 4. Thus, when the publication benefit in high quality journal is large enough, authors will incorporate multiple-submission in their submission strategy and the submission pattern in the first period is that $L \to H \to HL \to H$ as the paper's quality increases.

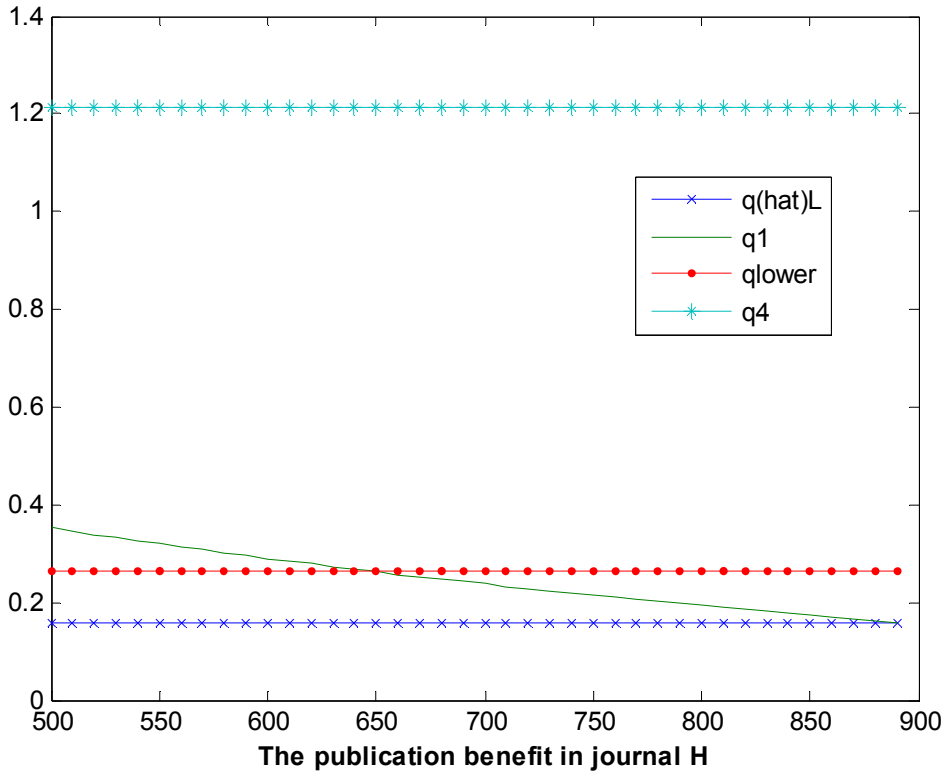

Figure 17: Expected submission benefits when B_H is very large

We can also use numerical simulation to provide some insights on how the quality thresholds in the two-period multiple-submission case change as the referee's quality assessment error varies. Let parameters take values $B_H = 20, B_L = 5, S_H = 3, S_L = 1, P_H = 2, P_L = 1$ and $\delta = 0.85$, so multiple-submission is possible. The following figure 17 shows how the quality thresholds q_5, q_4 change as σ varies, where q_5 is the quality threshold of submitting to only the low quality journal versus both journals and q_4 is the quality threshold of submitting to only the high quality journal versus both journals in the first period.

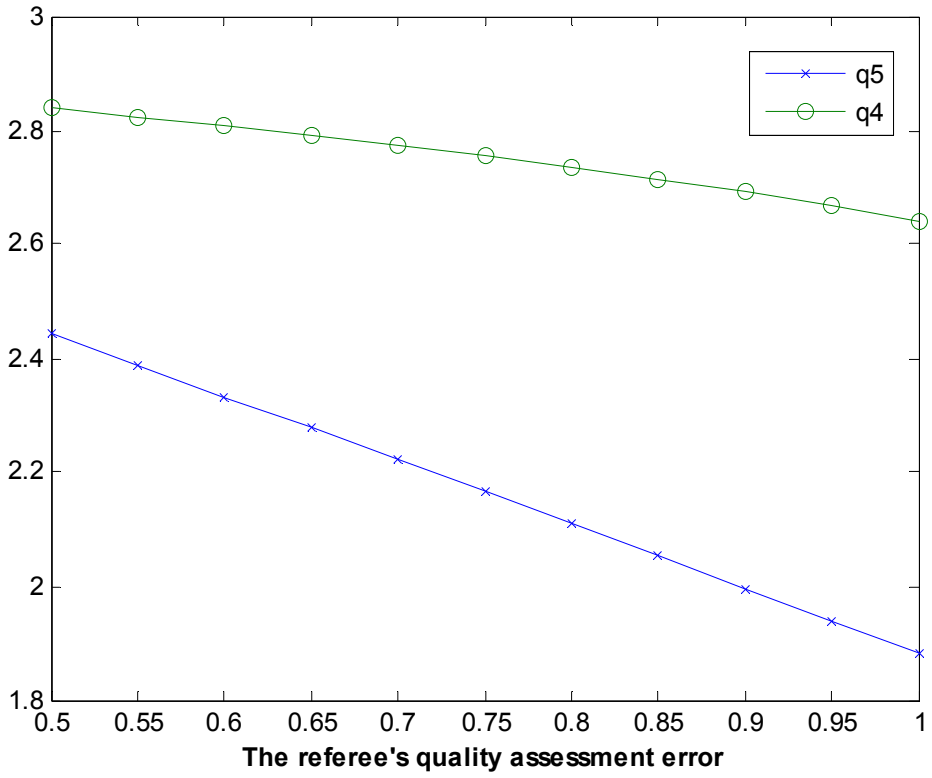

Figure 18: q5,q4 as quality assessment error changes

From above figure 18, we know that quality thresholds q_5 and q_4 decrease as the variance of the referee's quality assessment error σ increases and the difference between q_5 and q_4 widens as σ increases, which means that fewer papers will be submitted to only the low quality journal and the number of papers submitted to both journals increase as the referee's quality assessment gets less accurate.

We can also do simulation to reproduce figure10 to show how quality thresholds, which determine the author's submission strategy in the two-period and multiple-submission case, change as the discount factor δ varies. Choosing the parameters to be $B_H = 20, B_L = 5, S_H = 3, S_L = 1, P_H = 2, P_L = 1$ and $\sigma = 1$, as the discount factor δ changes from 0 to 1, with a 0.05 increase in each step, we did a numerical simulation to calculate and plot the values of quality thresholds q_L, q_0 and q_5 and q_4, which determine the author's submission strategy in the multiple-submission case according to the analysis in Corollary 5. The following figure 19 shows that q_4 decreases and q_5 increases as δ increases to the critical discount factor $\hat{\delta}$, which is consistent with figure 10. We know that the quality range in which multiple-submission occurs shrinks and authors are more likely to submit their papers to only one journal in the first period. Thus, there will be fewer papers submitted to both journals as authors become more patient. Also, if authors are sufficiently patient, the "multiple submissions" will always be dominated by "single submission". In other words, authors would rather wait and resubmit their papers in the second period if rejected than simultaneously submit the papers to both journals in the first period if they are patient enough.

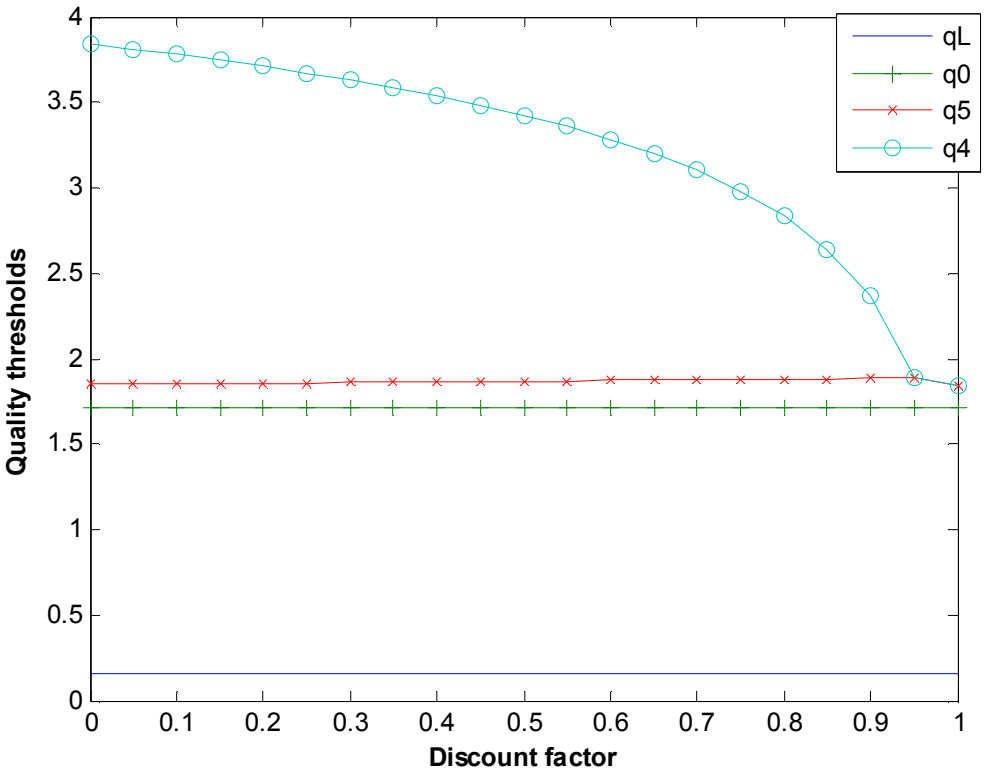

Figure 19: Quality thresholds as discount factor changes in multiple submissions

We can also do simulation to show how the author's quality threshold varies as both the variance of the referee's quality assessment error and the author's discount factor change. As authors' discount factor changes from 0 to 1 and the variance of referee's quality assessment error changes from 0.5 to 1 with 0.1 in each step, we did a numerical simulation on q_4 and q_5, which determine the author's submission strategy in multiple-submission case. The simulation results are shown in the following figure 20 and 21.

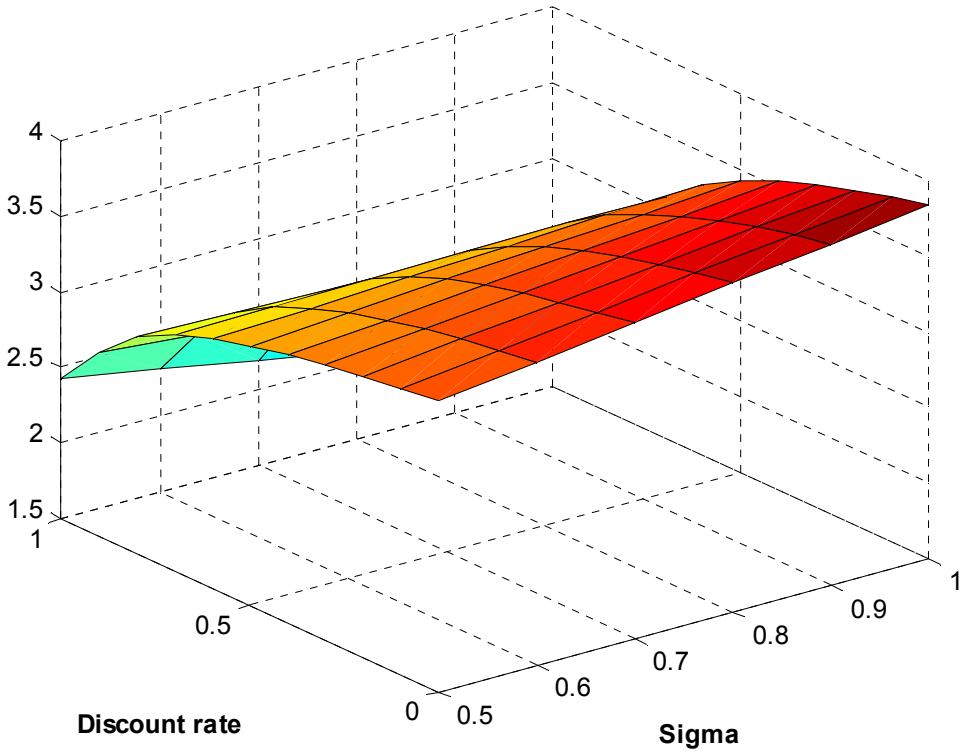

Figure 20: q4 as referees' assessment error and discount factor change

From the above figure, we know that when the author's discount factor is low, as the variance of the referee's quality assessment error increases, q_4 increases. In other words, if authors are impatient, the quality threshold between submitting to only journal H and both journals increases when the referee's quality assessment gets less accurate. Thus, it's more likely for an author to submit the paper to both journals than only journal H if the paper's quality is relatively high. When authors are patient, q_4 decreases as referee's quality assessment gets less accurate, and it's more likely for an author to submit the paper to only the high quality journal than both journals.

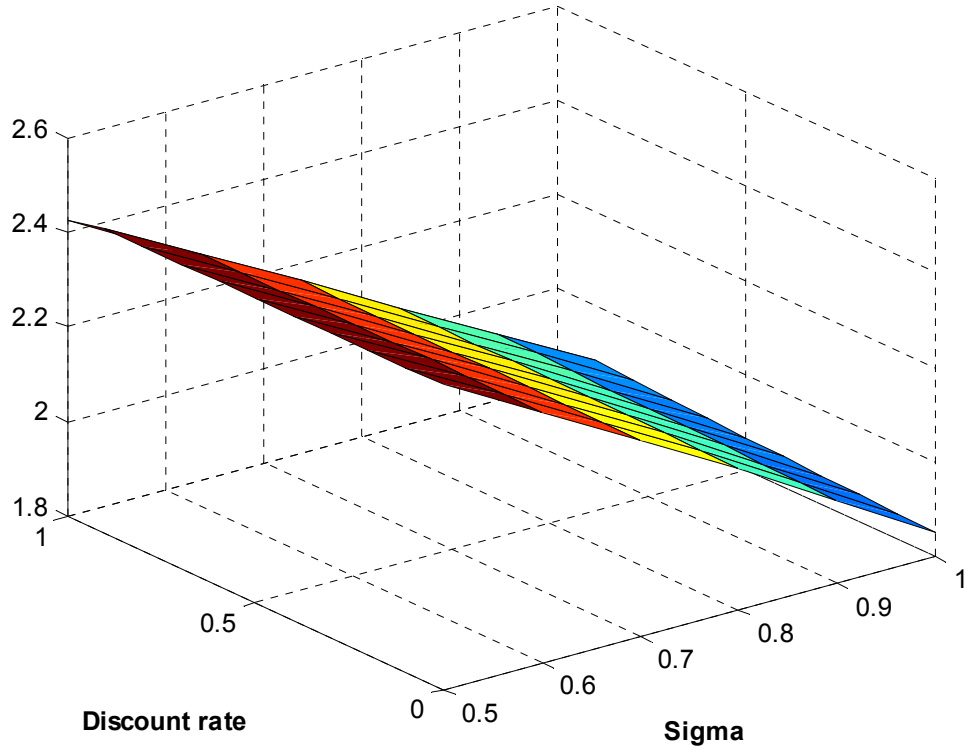

Figure 21: q5 as referees' assessment error and discount factor change

From the above figure, we know that q_5 increases as the variance of referee's quality assessment error decreases and q_5 increases as authors' discount factor increases. In other words, as authors become more patient and referee's quality assessment gets more accurate, the quality threshold of submitting to both journals and only journal L increases, which implies that it's more likely for an author to submit the paper to only the low quality journal than to both journals if the paper's quality is relatively low.

4.3 Simulation on per-period submission number and average quality

To illustrate that the per period number of submissions in the case of "multiple submissions" is higher than that in the "single submission" case and that allowing multiple submission will not necessarily reduce the quality of published papers, we assume that each author produces a paper with the random quality $q \sim N[1,1]$ and the referees' assessment error $\alpha \sim N[0,1]$, then according to the analysis in section 3.1 and 3.2, we can perform numerical simulations to see how the submission policy affects the expected quality of publications. The results from this simulation are reported in table 4 and table 5. [5]

The procedure of the simulation reported in table 4 and table 5 is as follows:

1) Given a group of parameter values as shown in the first column of table 4, according to an author's submission strategies in the case of "single submission" and "multiple submissions" illustrated in proposition 3 and corollary 4, we could get the quality thresholds q_0, $\hat{q}_L$, q_1 q_4 and q_5 [6], which are the critical quality thresholds determining the authors' submission strategy in the two-period single and multiple-submission cases.

2) According to the formulas (36),(37),(38) and (39) used to calculate the per-period number of submissions and the average quality of published papers in both journals under the "single submission" policy, we could get N_H, N_L, Q_H and Q_L, which are the expected per-period number of submission and average quality of accepted papers in the high and low quality

[5] We used Matlab 7.0 to derive the results reported in table 4.

[6] To calculate the quality thresholds in Matlab, we use the "finding zeros of functions" in the optimization toolbox and "cumulative normal distribution functions" in the statistical toolbox to do the numerical calculation.

journals in the two-period and single submission case. Similarly, according to the formulas in (54), (55), (56) and (57) we could calculate N_H^{MS}, N_L^{MS}, Q_H^{MS} and Q_L^{MS},[7] which are the expected per-period number of submission and average quality of accepted papers in the high and low quality journals in the two-period and multiple-submission case.

Table 4

Quality thresholds and critical discount rates

Critical qualities and discount rates / Parameters	$\hat{q}_L$	q_0	q_5	q_1	q_4	$\hat{q}_H$	$\hat{\delta}$
$B_H = 20, B_L = 5;\ s_H = 3, s_L = 1$ $P_H = 2, P_L = 1; \delta = 0.85, N = 1000$	0.1584	1.7184	1.8823	1.9697	2.6412	2.4186	0.9437
$B_L = 4.5$	0.2353	1.7184	1.8629	1.9344	2.5495	2.3403	0.9383
$B_H = 18$	0.1584	1.7794	1.9728	2.0564	2.6412	2.5196	0.9362
$P_L = 1.2$	0.2937	1.7184	1.8823	1.9526	2.4798	2.3849	0.9296
$P_H = 2.5$	0.1584	1.8497	2.0268	2.0929	2.6412	2.4993	0.9328
$s_L = 1.5$	0.6584	1.7184	1.8738	1.94	2.5586	2.3209	0.9281
$s_H = 3.5$	0.1584	2.2184	2.3865	2.4833	3.1697	2.9574	0.95
$\delta = 0.7$	0.1584	1.7184	1.8758	2.0752	3.1001	2.4186	0.9345

Table 4 shows the calibration results for those quality thresholds determining the author's submission strategies in both the single and multiple submission cases, and also reports the

[7] After getting the quality thresholds which determine authors' submission strategies in both single and multiple-submission policy regimes, we use the "cumulative normal distribution functions" and "numerical integration functions" to numerically calculate the expected per-period number of submissions and the average quality of submitted papers in both journals

critical discount rates under different groups of parameters, from which we could know whether some authors will choose multiple submission.

Table 5: Per-period number of submissions and average quality of papers accepted for publication in both journals under the two different policy regimes

Policy Regimes / Parameter Values	Single submission				Multiple submissions				
	Per-period number of submissions in high and low quality journals		Average quality of the accepted papers in high and low quality journals		Per-period number of submissions in high and low quality journals			Average quality of the accepted papers in high and low quality journals	
	N_H	N_L	Q_H	Q_L	N_H^{MS}	N_L^{MS}	$\tilde{N}_{H,L}$	Q_H^{MS}	Q_L^{MS}
$B_H=20, B_L=5;\ s_H=3, s_L=1$ $P_H=2, P_L=1; \delta=0.85, N=1000$	180.22	746.94	2.695	1.507	198.88	773.88	138.43	2.66	1.549
$B_L=4.5$	187.63	723.40	2.68	1.52	203.17	748.15	133.48	2.65	1.56
$B_H=18$	158.56	750.28	2.74	1.51	175.40	773.88	114.96	2.70	1.549
$P_L=1.2$	183.78	706.30	2.69	1.53	198.88	727.60	119.34	2.66	1.562
$P_H=2.5$	147.35	751.74	2.766	1.512	160.22	773.88	101.89	2.736	1.549
$s_L=1.5$	196.95	579.51	2.66	1.72	208.46	604.41	131.57	2.643	1.757
$s_H=3.5$	72.84	779.83	3.09	1.57	85.59	792.40	67.78	3.03	1.604
$\delta=0.7$	159.08	751.03	2.74	1.51	200.32	788.07	172.71	2.657	1.588

Note: The above numerical results in table 3 are calculated from Matlab programming.

The first four columns in table 5 are the results in the case of "single submission" and the last four columns report the results in the case of "multiple submissions". The rows give the results under different parameter values. Given the set of parameter values, we can compare the expected per-period number of submissions and the average quality of accepted papers in both journals under the two policy regimes. We can also see from the table how the submission number and

average quality of accepted papers change as the parameters change. The first row gives the results under a set of base parameter values. The other seven rows report the results when we change only one of the parameter values and hold the others as constants, and we can compare the results to the base scenario in the first row.

At first, we reduce the benefits of publication in the journals and the results are shown in the second and third rows. When the benefit of publishing papers in the low quality journal is reduced from 5 to 4.5, the expected per-period number of submissions to journal L decreases from 746.94 to 723.4 under "single submission" and decreases from 773.88 to 748.15 under "multiple submissions", and the average quality of the accepted papers in journal L increases under both policy regimes. When the low quality journal's publication benefit decreases, it becomes less attractive and fewer low quality papers will be submitted to journal L, thus the average quality of accepted papers will increase. At the same time, the number of submissions to the high quality journal will increase and the average quality of papers accepted for publication in journal H will decrease under both policy regimes. As the low quality journal's publication benefit decreases, the high quality journal becomes more attractive and more papers which were submitted to journal L originally will be submitted to journal H, thus decrease the average quality of accepted papers in the high quality journal. In addition, the number of papers submitted to both journals in the multiple-submission case will decrease from 138.48 to 133.48.

When the benefit of publication in the high quality journal is reduced from 20 to 18, the submission number in journal H decreases and the average quality of accepted papers in journal H increases under both policy regimes. Although the submission number in journal L increases, the average quality of accepted papers in journal L also increases under "single submission", and both the submission number and the average quality of accepted papers in journal L remain the same under "multiple submission". Because decreasing the high quality journal's publication

benefit will not affect the quality threshold of submitting to only the high quality journal and both journals in the first period since there is no change on the expected submission benefit on the low quality journal, thus there will be no change on the submission number and average quality of accepted papers in journal L in the multiple-submission case. The forth and fifth rows show the results as we raise the prices of submission to the journals. Not surprisingly, the results are similar as what are shown in the second and third rows because increasing the submission prices has the same effect on the authors' welfare as decreasing the benefits of publication in the journals.

The sixth and seventh rows report the results as we increase the journals' standards. When the low quality journal's standard s_L is raised from 1 to 1.5, the per-period number of submissions to journal L decreases from 746.94 to 579.51 under "single submission" and decreases from 773.88 to 604.41 under "multiple submission", and the average quality of the papers accepted for publication in journal L increases under both policy regimes. At the same time, the number of submissions to journal H increases and the average quality of accepted papers in journal H decreases under both policy regimes. As the low quality journal's standard increases, fewer low quality papers will be submitted to journal L and the average quality of accepted papers will increase. Also, the high quality journal becomes more attractive and some papers will be switched from journal L to H, thus the submission number increases and the average quality of accepted papers decreased in the high quality journal. As we increase the high quality journal's standard s_H from 3 to 3.5, the number of submissions to journal H decreases and the average quality of accepted papers in journal H increases under both policy regimes. Although the number of submissions to journal L increases, the average quality of accepted papers in journal L also increases under both policy regimes. As the high quality journal's standard increases, fewer low quality papers will be submitted to journal H and the average quality of accepted papers will increase. Also, the low quality journal becomes more attractive and some papers will be switched

from journal H to L, thus the submission number increases and the average quality of accepted papers also increases in the low quality journal.

At last, we decrease the discount factor from 0.85 to 0.7, which implies that authors in the economy become less patient. From the results shown in the last row, we can see that under "single submission", the per-period number of submissions decreases in the high quality journal and increases in the low quality journal. This is not surprising. The intuition is that when only allowing single submission in each period, the author's trade off between submitting to the high and low quality journal, and as they become less patient they are less capable of suffering from no publication today, thus they'd rather submit to the low quality than the high quality journal today because if they are rejected by journal H they can just get a small discounted expected payoff by submitting their papers to journal L tomorrow. Under "multiple submissions", as the authors get less patient, the per-period number of submissions to both journals will increase from 198.88 to 200.32. The intuition is that when "multiple submissions" is allowed the authors trade off between submitting their papers today and tomorrow, as they discount the future less they are more willing to wait until tomorrow to submit.

As shown in table 5, the average quality of accepted papers in the low quality journal under "multiple submissions" is greater than its counterpart under "single submission". Therefore, allowing multiple submissions may not necessarily deteriorate the quality of published papers.

As the variance of the referee's quality assessment error decreases, e.g. $\sigma = 0.01$, the calibration results for quality thresholds, the per-period number of submission and average quality of accepted papers are reported in table 6 and table 7 respectively.

Table 6

Quality thresholds and critical discount rates when referee's assessment is precise

Critical qualities and discount rates / Parameters	$\hat{q}_L$	q_0	q_5	q_1	q_4	$\hat{q}_H$	$\hat{\delta}$
$B_H = 20, B_L = 5;\ s_H = 3, s_L = 1$ $P_H = 2, P_L = 1; \delta = 0.85, N = 1000$ $\sigma = 0.01$	0.9916	2.9872	2.9889	2.9899	2.9968	2.9948	0.9536

As shown in table 6, when the referee's quality assessment is getting very accurate, the quality thresholds of submitting to the high (low) quality journal under both submission policy regimes are very close to its quality standard $s_H = 3$ ($s_L = 1$). This is not surprising because as noises on quality assessment go away, only those papers with quality matching journals' standards will be accepted for publication. Authors know this fact and will act accordingly since submission is costly.

Still assuming that $B_H = 20, B_L = 5, S_H = 3, S_L = 1, P_H = 2, P_L = 1$, $\delta = 0.85$ and $N = 1000$, compared with the results shown in table 5, we know that when the referee's quality assessment gets more accurate, or as σ decreases from 1 to 0.01, per-period number of submissions to the high and low quality journals decrease significantly under both the single and multiple-

submission policy regimes. The average quality of accepted papers in both high and low quality journals increase in the single submission and the multiple-submission cases. This is because that under the chosen parameters or as the ratios of publication benefits to publication costs are relatively high, both the quality thresholds of submitting to the high and low quality journals are below their quality standards, and the average quality of accepted papers will approach toward the quality standards thus increase as the referee's quality assessment becomes more accurate.

Table 7

Per-period number and average quality of submission when referee's assessment is precise

Policy Regimes / Parameter Values	Single submission				Multiple submissions				
	Per-period number of submissions in high and low quality journals		Average quality of the accepted papers in high and low quality journals		Per-period number of submissions in high and low quality journals			Average quality of the accepted papers in high and low quality journals	
	N_H	N_L	Q_H	Q_L	N_H^{MS}	N_L^{MS}	$\tilde{N}_{H,L}$	Q_H^{MS}	Q_L^{MS}
$B_H = 20, B_L = 5;\ s_H = 3, s_L = 1$ $P_H = 2, P_L = 1; \delta = 0.85, N = 1000$ $\sigma = 0.01$	23.30	480.65	3.3738	1.7235	23.37	480.74	0.434	3.3737	1.7238

We did numerical simulation to show how the per-period number of submission and average quality of accepted papers in the high and low quality journals vary as authors' discount rates and referees quality assessment error change under both the single and multiple submission policy regimes. As authors' discount rates change from 0 to 1 and the variance of referee's quality

assessment error changes from 0.5 to 1 with 0.1 in each step, the simulation results on per-period submission number are shown in the following figures.

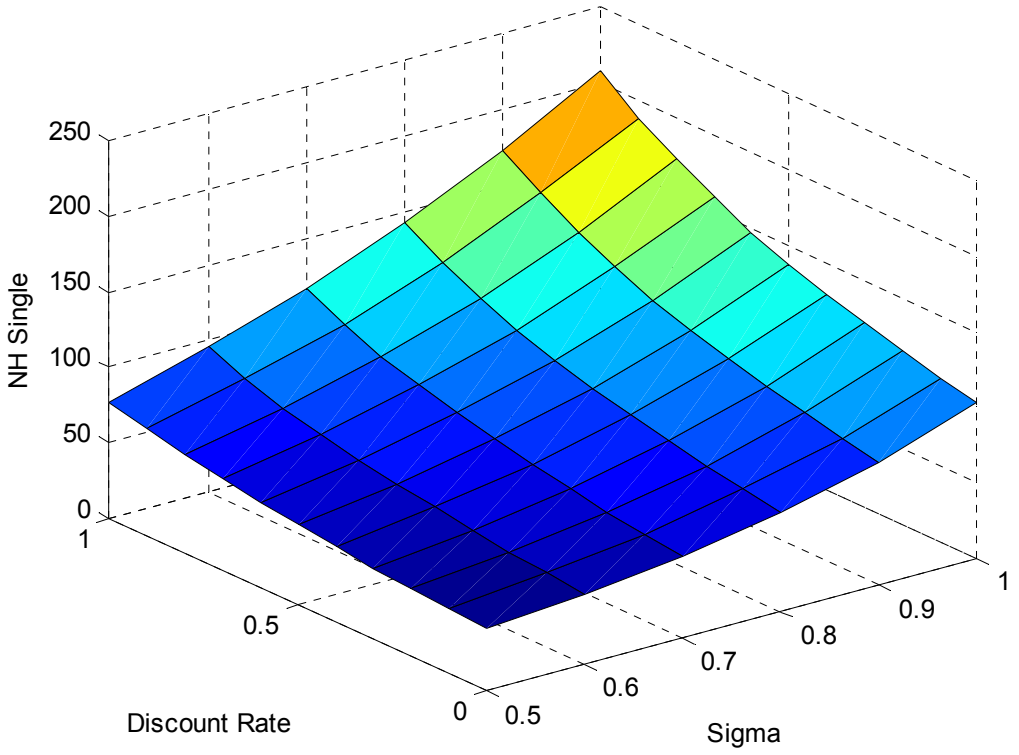

Figure 22: Expected per-period number of submission to the high quality journal under single submission policy

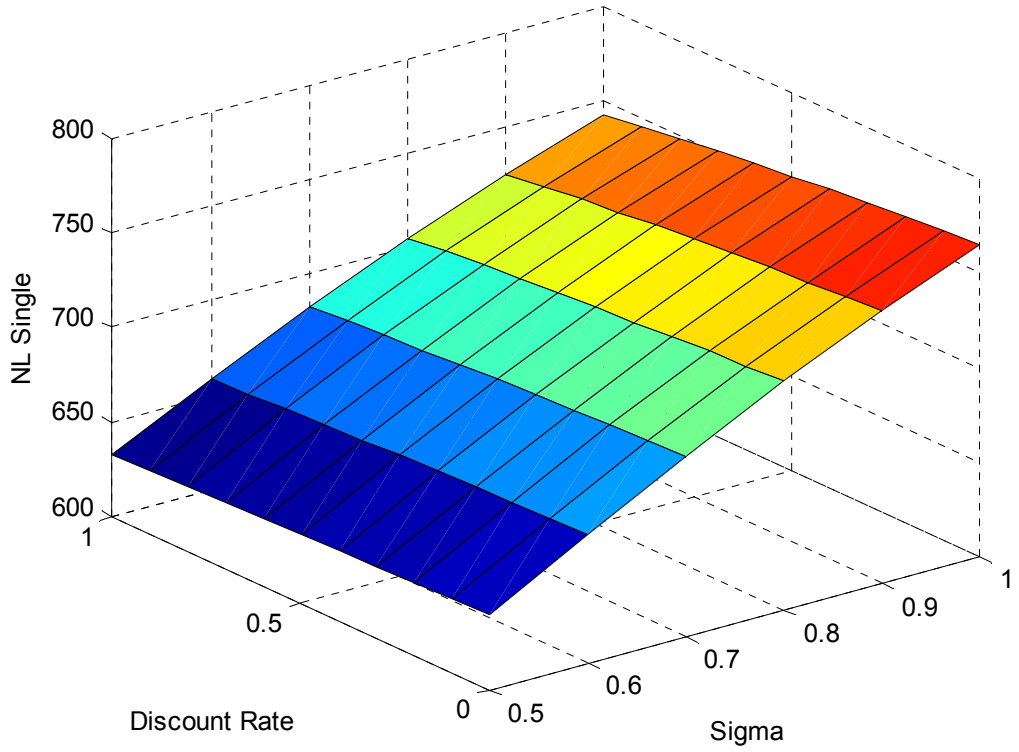

Figure 23: Expected per-period number of submission to the low quality journal under single submission policy

From the numerical simulation results, we know that under single submission policy, the expected per-period submission number to the high quality journal increases as authors become more patient and also increases as referee's quality assessment gets less accurate. N_H in single submission case reaches the highest level when $\delta = 1$ and $\sigma = 1$. The expected per-period submission number to the low quality journal decreases as authors become more patient and increases as referee's quality assessment gets less accurate. N_L in single submission has the largest value when $\delta = 0$ and $\sigma = 1$.

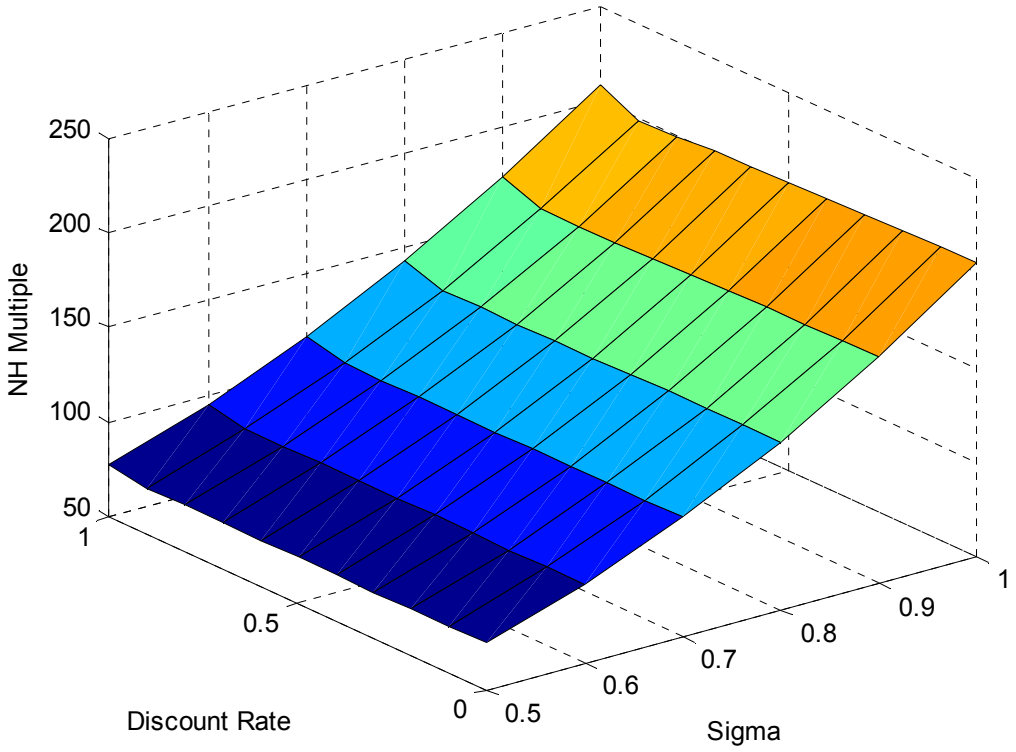

Figure 24: Expected per-period number of submission to the high quality journal under multiple-submission policy

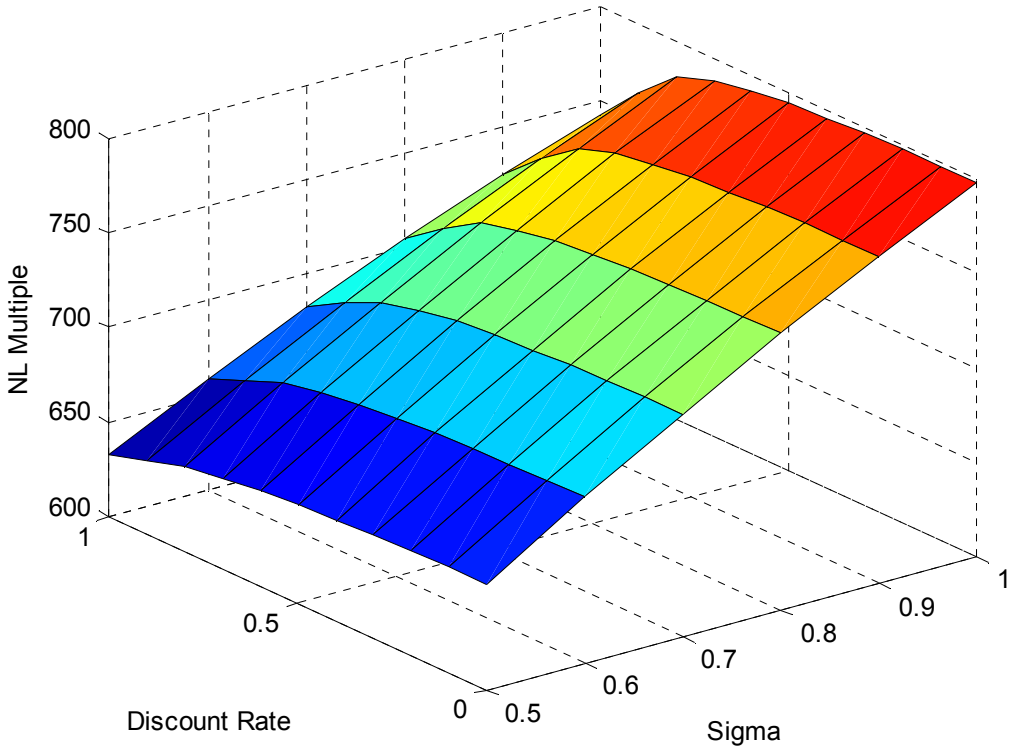

Figure 25: Expected per-period number of submission to the low quality journal under multiple-submission policy

From the numerical simulation results, we know that under multiple submission policy, the expected per-period number of submissions to the high quality journal increases as the referee's quality assessment gets less accurate and it decreases as authors become more patient when discount factor is relatively small. But N_H^{MS} will increase as authors become more patient when the discount factor is large. N_H^{MS} reaches the highest level when $\delta = 1$ and $\sigma = 1$. The expected per-period submission number to the low quality journal decreases as authors become more patient and increases as referee's quality assessment gets less accurate. N_L^{MS} has the largest value when $\delta = 0$ and $\sigma = 1$.

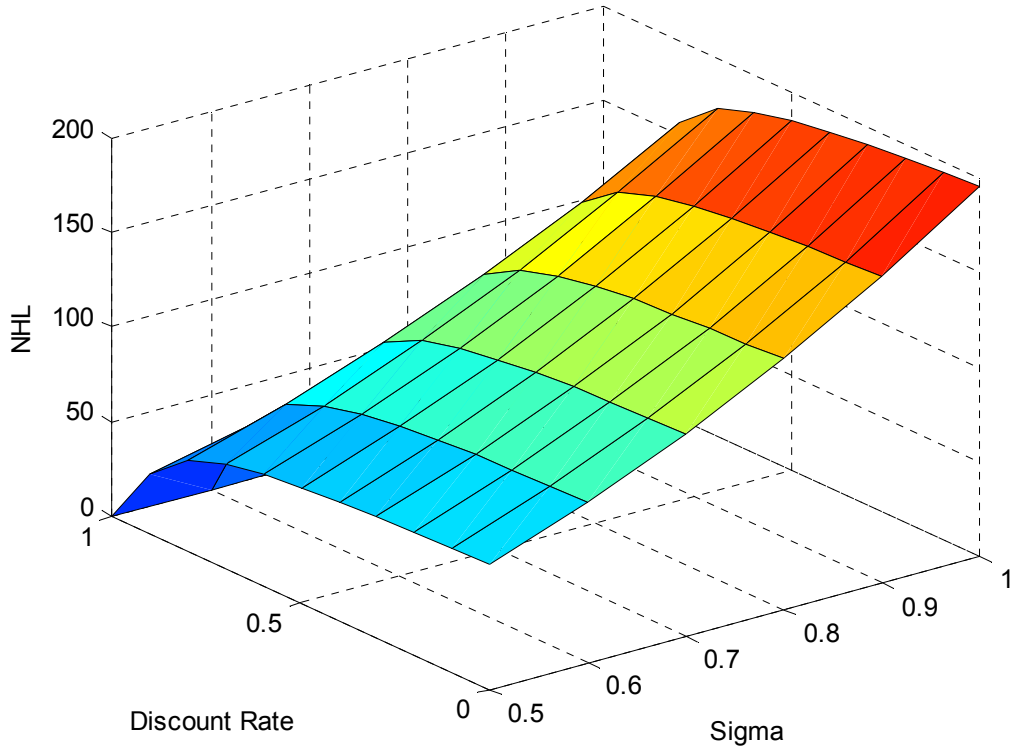

Figure 26: Expected per-period number of submission to both journals under multiple-submission policy

From the numerical simulation results, we know that under multiple submission policy, the expected per-period submission number to both the high and low quality journal decreases as authors become more patient and it increases as the referee's quality assessment gets less accurate. When authors become more patient, they would rather wait and re-submit in next period if rejected than submit the papers to both journals simultaneously in the first period, thus N_{HL} will decrease. When the referee's quality assessment gets less accurate, authors will more likely to use this chance to submit papers which may not be submitted when the referee has an accurate quality assessment. N_{HL} reaches the highest level when $\delta = 0$ and $\sigma = 1$.

Similarly, we did numerical simulations to show how the average quality of accepted papers in the high and low quality journals vary as authors' discount rates and the referee's quality assessment error change under both the single and multiple submission policy regimes. As authors' discount rates change from 0 to 1 and the variance of the referee's quality assessment error changes from 0.5 to 1 with 0.1 in each step, the simulation results on average quality are shown in the following figures.

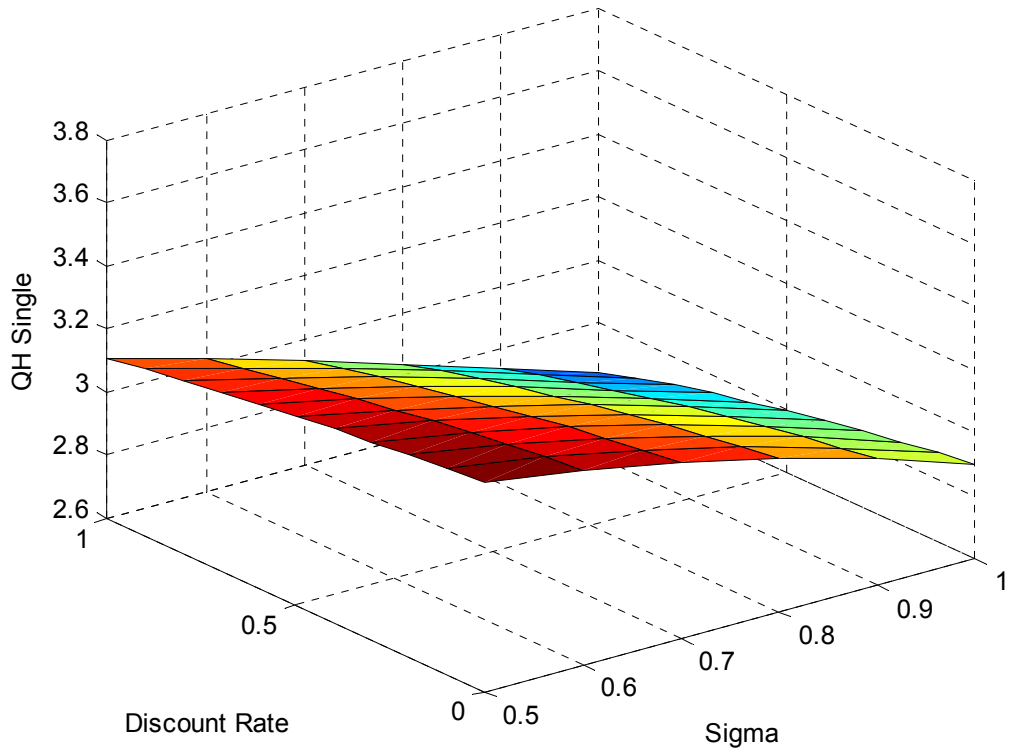

Figure 27: Average quality of accepted papers in the high quality journal under single submission policy

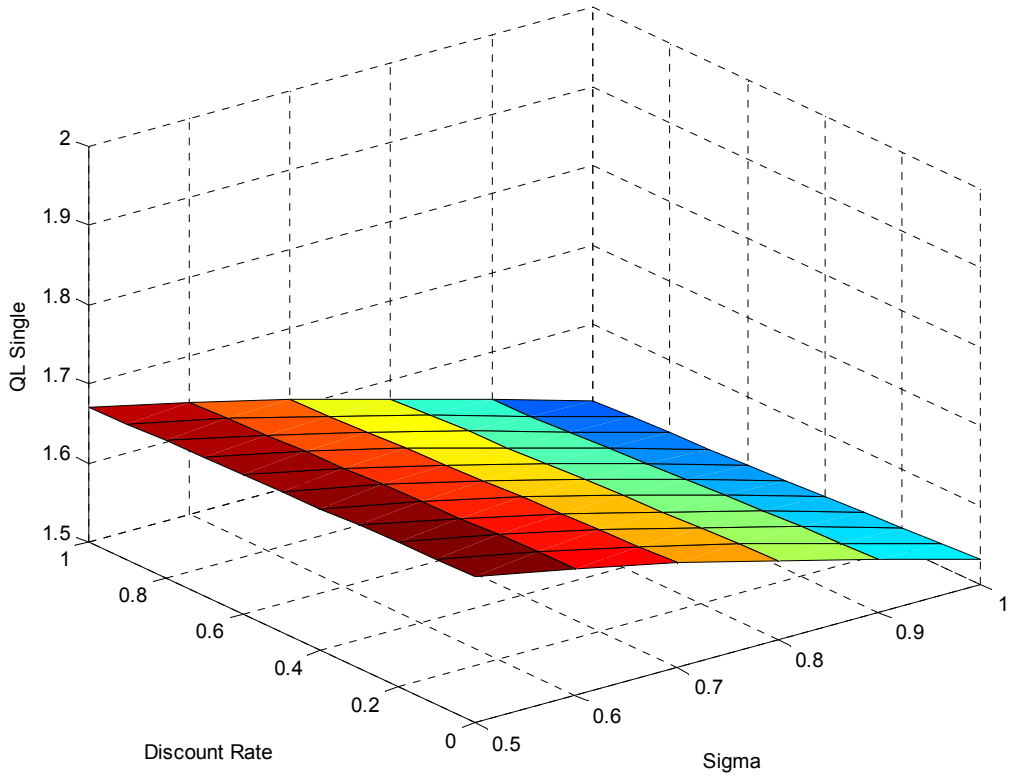

Figure 28: Average quality of accepted papers in the low quality journal under single submission policy

From the numerical simulation results, we know that under a single submission policy, the average quality of papers accepted in the high quality journal Q_H decreases as the referee's quality assessment becomes less accurate and it also decreases as authors become more patient. The average quality of papers accepted in low quality journal Q_L decreases as the referee's quality assessment becomes less accurate and it also decreases as authors become more patient.

From the numerical simulation results shown in figure 29 and figure 30, we know that under multiple submission policy, the average quality of papers accepted in the high quality journal Q_H^{MS} decreases as the referee's quality assessment becomes less accurate and it increases as authors become more patient. The average quality of papers accepted in low quality journal Q_L^{MS} decreases as the referee's quality assessment becomes less accurate and it decreases as authors become more patient.

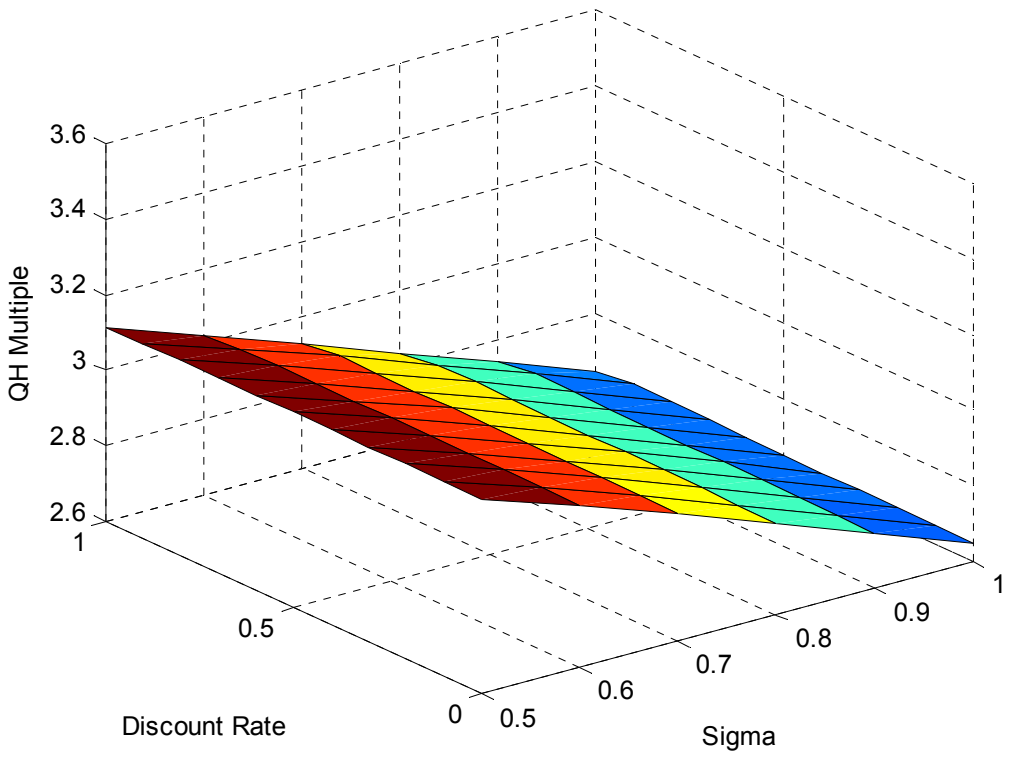

Figure 29: Average quality of accepted papers in the high quality journal under multiple-submission policy

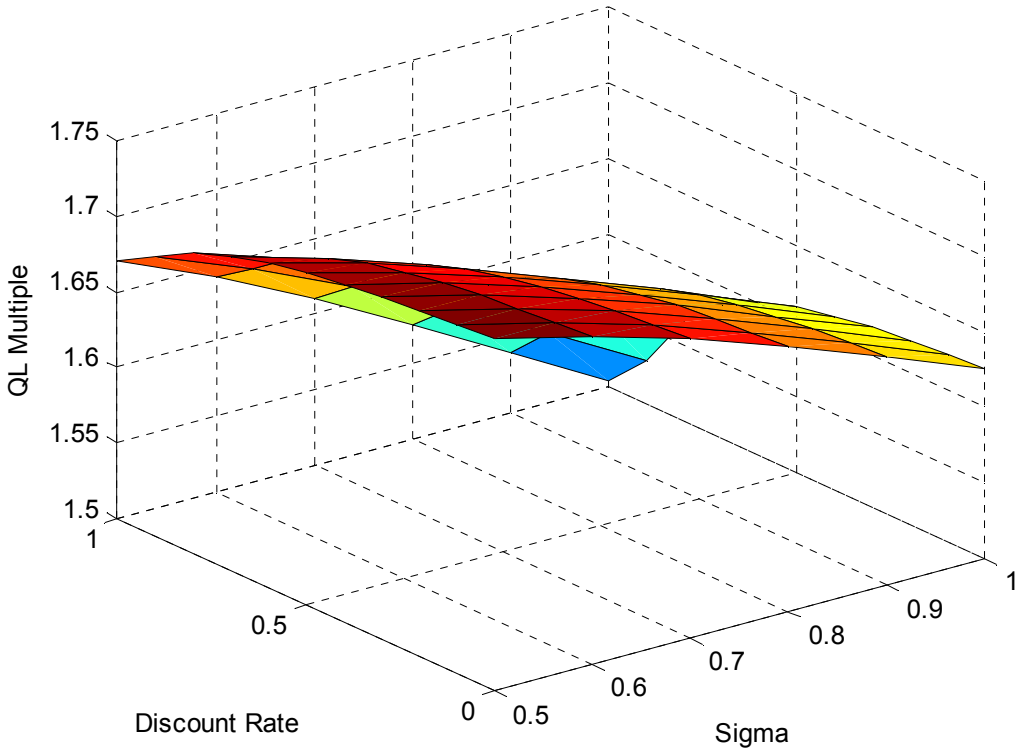

Figure 30: Average quality of accepted papers in the low quality journal under multiple-submission policy

CHAPTER 5. CONCLUSIONS

We have investigated an author's submission strategies in both the case of single and multiple submissions. We find that given the ratio of publication benefit to submission fee in the low quality journal, if authors' are patient enough they will never submit their papers to both journals simultaneously. Otherwise, whether the multiple-submission may occur in their optimal submission strategy depends on the magnitude of the publication benefit in the high quality journal. When the publication benefit in the high quality journal is small enough, authors will never include multiple-submission in their strategy. When the publication benefit in the high quality journal is relatively large, multiple-submission is possible and an author's strategy depends on the paper's quality. As the paper's quality increases, the submission decision changes from submitting to only the low quality journal, to submitting to both journals then to submitting to only the high quality journal. When the publication benefit in the high quality journal is large enough, an author's submission decision changes from submitting to only the low quality journal, to submitting to only the high quality journal, to submitting to both journals, then to submitting to only the high quality journal as the paper's quality increases.

Through numerical simulations, we analyzed authors' submission strategies and investigated how the expected per-period number of submission and average quality of published papers in both journals change as the author's discount factor and the referee's quality assessment error change. We find that if multiple submissions were allowed, the average quality of accepted papers for publication could be higher or lower than that in the single submission case. Therefore, allowing multiple submissions may not necessarily deteriorate the average quality of published papers. In addition, we find that, as authors become less patient they are more likely to choose multiple submissions. If authors are patient enough, single submission will be the dominant strategy. In

reality, multiple submissions are prohibited by most of the academic journals, thus those authors who are impatient or have small discount factors will be worse off under the prevailing single submission policy. From the simulation results we know that allowing multiple submissions may not necessarily deteriorate journals' quality. The simulation results also show that a less (more) patient author is more likely to submit his paper to the low (high) quality journal.

Our model is based on four main assumptions. First, we assume that authors are identical and this is embodied in two aspects: 1) In each period they produce one paper with the same distributed random quality; 2) They have the same discount factor. In reality, some authors are more patient than others. If we assume that authors have heterogeneous discount factors, the results of comparing expected per-period number of submissions under the two policy regimes will be different. The second assumption of our model is that the quality standards of journals are common knowledge and authors know the quality of their papers perfectly. This assumption is different from what's analyzed in Ellison (2002b). In his paper, Ellison assumed that the quality standards of journals are social norms and authors are subject to overconfidence bias (they think their papers are slightly better than they really are). Referees don't know the standards perfectly and their efforts of trying to conform to social norms will eventually lead to a shift of the social norms, given the assumption that authors are subject to overconfidence bias. In our model, the quality standards of journals are common knowledge so there is no shift of social norms, and because we assume authors know their papers' quality perfectly, they would not update the information according to their submission history. If we assume authors don't have perfect information about their papers' quality, then their submission strategies will be dependent on the referee's decision or their submission history. Our third assumption is that the errors in the referee's assessment of a paper's quality are uncorrelated. Finally, we assume that there are only two journals in the economy, thus a paper can be submitted at most twice. Without these assumptions, the results will be different from what we get in previous analysis. What happens to

author's submission strategies if we change these assumptions are waiting for further investigation.

Appendix

Notations to be used in the dissertation

Notations	Description
q	a paper's quality
$F(q)$	$q \sim F(q)$ and $F(q)$ is the cumulative density function of q and $f(q)$ is the probability density function of q
s	Referees' quality assessment
α	Referee's quality assessment error ($s = q + \alpha$)
$G(\alpha)$	$\alpha \sim G(\alpha)$ and $g(\alpha)$ is the $p.d.f$ of α
B_H	Publication benefit in high quality journal
B_L	Publication benefit in low quality journal
s_H	Quality standard of high quality journal
s_L	Quality standard of low quality journal
P_H	Submission fee charged by high quality journal
P_L	Submission fee charged by low quality journal

Notations to be used in the single period case in Chapter 3

Notation	Description
$\pi_j(q)$	the probability of being accepted for publication in journal j, $j = H, L$
$M_j(q)$	expected payoff of submission in journal j in single submission single period case , $j = H, L$
$M_{H,L}(q)$	expected payoff of submitting to both journals
$\hat{q}_H$	the quality threshold between submitting to high and low quality journal in single submission single period case ($\hat{q}_H$ is determined by $M_H(\hat{q}_H) = M_L(\hat{q}_H)$)
$\hat{q}_L$	the quality threshold between submitting to low quality journal and no submission in single submission single period case ($\hat{q}_L$ is determined by $M_L(\hat{q}_L) = 0$)
q_0	the quality at which the expected submission benefit in high quality journal is zero (q_0 is

	determined by $M_H(q_0)=0$)
q_2	the quality threshold of submitting to only journal H and both journals in single period (q_2 is determined by $M_H(q_2)=M_{H,L}(q_2)$)
q_3	the quality threshold of submitting to both journals and only journal L in single period (q_3 is determined by $M_L(q_3)=M_{H,L}(q_3)$)

Notations to be used in the multiple-period case in Chapter 3

δ	Authors' discount factor and $\delta \in [0,1]$
$\hat{\delta}$	the critical discount factor, when $\delta > \hat{\delta}$ single submission is the dominant strategy
$M_{H,L}(q)$	expected payoff of submitting to both journals
$M_{1H}(q)$	expected payoff of submitting to both journals
$M_{1L}(q)$	expected payoff of submitting to journal L in first period
q_1	quality threshold of submitting to journal H and L in first period (q_1 is determined by $M_{1H}(q_1)=M_{1L}(q_1)$)
q_4	quality threshold of submitting to only journal H and both journals in first period (q_4 is determined by $M_{H,L}(q_4)=M_{1H}(q_4)$)
q_5	quality threshold of submitting to only journal L and both journals in first period (q_5 is determined by $M_{H,L}(q_5)=M_{1L}(q_5)$)
N_j	expected per-period number of submissions to journal j in single submission, $j=H,L$

Q_j	the average quality of the papers accepted for publication in journal j in single submission, $j = H, L$
N_j^{MS}	expected per-period number of submissions to journal j in multiple submissions, $j = H, L$
Q_j^{MS}	the average quality of the papers accepted for publication in journal j in multiple submissions, $j = H, L$

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