Parameter Design for Self-Organizing Peer Review on National Preprint Platform Based on Response Surface Analysis: Postprint

Authors: Wang Lingfeng, Wang Shenpeng

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Abstract

[Purpose/Significance] To ensure the quality of papers on the national preprint platform, peer review must be introduced. Self-organized peer review has garnered increasing attention in recent years. To achieve the performance targets expected by the management institutions of the national preprint platform, research on the optimization design of key parameters for self-organized peer review is required.

[Method/Process] With paper review completion rate (CR), reviewer task distribution balance degree (TBD), and average paper review time (A_r_{time}) as three dependent variables for evaluating self-organized peer review performance, and with reviewer rest time, reviewer rejection rate, number of authors, and review qualification ratio as four key independent variables, response surface analysis was performed on data obtained from Box-Behnken sampling design to derive quantitative relationships between the performance evaluation dependent variables and the key parameter independent variables.

[Results/Conclusion] Through different combinations of the four key independent variables, the national preprint platform can adjust the three performance metrics of self-organized peer review, thereby ensuring the average quality of papers published on the platform.

Full Text

Parameter Design for Self-Organizing Peer Review on the National Preprint Platform Based on Response Surface Analysis

Wang Lingfeng, Wang Shenpeng
Business School, Guilin University of Electronic Technology, Guilin 541004

[**Purpose/Significance**] To ensure paper quality on the National Preprint Publishing Platform of China, peer review must be introduced. Self-organizing peer review has attracted increasing attention in recent years. To achieve the performance levels expected by the platform' s management agency, optimization of key parameters for self-organizing peer review is necessary.

[**Method/Process**] Using paper review completion rate, reviewer task allocation balance, and average paper review time as three dependent variables for evaluating self-organizing peer review performance, and using four key parameters—reviewer rest time, reviewer rejection rate, number of authors, and review qualification ratio—as independent variables, we conducted response surface analysis on data obtained from Box-Behnken sampling design to derive quantitative expressions relating performance evaluation dependent variables to key parameter independent variables.

[**Results/Conclusions**] Through different combinations of values for the four key parameter independent variables, the National Preprint Publishing Platform can adjust the three performance parameters of self-organizing peer review to ensure the average quality of papers published on the platform.

Keywords: National Preprint Publishing Platform; paper quality; self-organizing peer review; Box-Behnken design; response surface analysis

1 Introduction

Scientific and technological information constitutes a critical supporting element of the national innovation system. China' s "Recommendations for Formulating the 14th Five-Year Plan for National Economic and Social Development and Long-Range Objectives for 2035," issued in 2020, proposed constructing a national high-end exchange platform for scientific research papers and scientific and technological information, listing this as one of seven key points for strengthening national strategic scientific and technological capabilities. This marked the first time China included scientific and technological information in a central-level document. The Institute of Scientific and Technical Information of China (ISTIC), under the Ministry of Science and Technology, built the China Open Access Archive (COAA), with the website https://coaa.istic.ac.cn/. The platform, launched at the end of 2022, currently includes three sub-platforms: the National Research Papers Platform, the National Preprint Platform, and the National Scientific Journals Platform (National Knowledge Repository Platform). The preprint platform, accessible at https://coaa.istic.ac.cn/preprint, aims to promote rapid publication and open sharing of Chinese scientific research papers, ensuring authors' priority rights. The platform provides electronic acceptance certificates and integrates several of China' s most representative preprint websites.

The National Preprint Platform accepts preprint research papers in both Chinese and English. After real-name registration, authors can submit manuscripts, which receive DOI numbers after passing the most essential basic review. How-

ever, to ensure paper quality, a peer review mechanism must be introduced. Existing quality assurance mechanisms for preprint platforms have limitations. Recent years have seen growing attention toward self-organizing peer review. To achieve the performance expected by the National Preprint Platform management agency, research on optimizing key parameters for self-organizing peer review is required.

Current quality assurance mechanisms for preprints include: (1) technical formal review by preprint staff, which checks whether authors work at legitimate research institutions, have basic academic qualifications, pass plagiarism checks, and have credible researcher endorsements; (2) volunteer recruitment, which requires no payment but suffers from academic disagreements and potential personal conflicts; and (3) free reader commentary, where reviewers can speak freely but some papers may remain unreviewed for long periods, and authors might give false positive reviews to each other or deliberately downgrade competitors' work. The high-end positioning of the National Preprint Platform requires a more comprehensive paper quality assurance mechanism.

Preprints lack the peer review of journals. Although major preprint databases in Europe and America, such as bioRxiv in biology and arXiv in computer science, receive tens of thousands of submissions annually, most biology papers are still eventually published in journals. The same phenomenon occurs in China. The number of Chinese journal articles published is over 500 times the total number of preprints from China' s major preprint platforms (China Science Paper Online, Chinese Academy of Sciences Preprint, and China Preprint Service System). This discrepancy arises because research management departments in personnel promotion, project application, and other areas of concern to researchers do not treat preprint articles as equivalent to journal articles. Since journals are recognized by research management departments, serving as a reviewer for journals carries certain reputational value beneficial to career development, motivating researchers to review for journals voluntarily. Preprint articles currently lack such recognition, making researcher participation in preprint peer review a challenge.

Self-organizing peer review theoretically applies perfectly to preprints. Its greatest characteristic is that algorithms rather than humans complete the two key processes of searching for reviewers and matching reviewers with papers, hence the term "self-organizing." Once activated, the algorithm operates without human intervention, handling the matching of reviewers and papers and managing unexpected situations in the peer review process. Under the same conditions of reviewer fairness and paper materials, self-organizing peer review is generally superior to traditional editor-invited peer review in terms of impartiality and speed. As an innovation in peer review models over the past decade, self-organizing peer review has certain theoretical and applied value. With the National Preprint Platform launching at the end of 2022, applying self-organizing peer review to the platform naturally becomes an important issue for the next stage of platform construction.

The basic approach involves the platform using algorithms to match researchers who submit papers within a discipline to review each other' s work under double-blind conditions. The relationship between the number of papers submitted and paper authors follows Lotka' s distribution. Researchers who continuously reject review invitations or exceed review time limits face penalties. Penalized researchers have all papers they submitted or co-authored suspended from access, with other co-authors notified of the penalty, using personal reputation damage and peer pressure to motivate timely review completion. In addition to penalty mechanisms, point-based incentive mechanisms and token incentive mechanisms for self-organizing peer review have also been discussed.

The key parameter design problem arises because four key parameters affect self-organizing peer review performance: reviewer rest time, reviewer rejection rate, number of authors, and review qualification ratio. The simulation period is 365 days; papers exceeding this period are considered incomplete. By adjusting Lotka distribution parameters, different disciplinary scales can be simulated.

2.1 Self-Organizing Peer Review Process Rules

The simulation establishes the following rules: (1) Three reviewers form a group to review one paper. To increase the probability of expert review, matching occurs at the secondary discipline level. (2) Reviewers cannot review papers they co-authored. (3) A reviewer' s task volume equals their submitted paper count multiplied by 3. For example, if Author A submits 1 paper and Author B submits 2 papers, then A's review task is 3 papers and B's is 6 papers. (4) When multiple qualified reviewer groups exist, priority goes to the group with the most uncompleted review tasks. (5) If multiple groups have identical numbers of uncompleted tasks, selection is random. (6) If no qualified group exists, the paper-reviewer matching sequence moves the paper to the end. (7) Penalties for overdue or repeated rejection involve moving all papers submitted by the penalized reviewer to the end of the matching sequence. (8) The maximum review time for a reviewer is set at 60 days, as most journals require reviewers to complete within two months. The minimum is set at 10 days, as some top journals require review within two weeks.

2.2 Self-Organizing Peer Review Performance Indicators

Performance evaluation indicators and definitions are detailed in Table 1. Using three reviewers per paper as an example, review task saturation means: if an author has review qualifications and submits 2 papers requiring review, their task volume is 6. If they actually complete 3 reviews in a simulation period, their task saturation is 50%. For most authors, writing more than 4 quality papers annually is uncommon, so the maximum papers reviewed per year per author is capped at 4, with excess papers automatically deferred to the next year.

2.3 Parameter Value Settings

Based on Publons' Global State of Peer Review report, the median paper review time is approximately 14.7 days, rounded to 15 days. Using a 5-day step size accounts for a 5-day work week. Considering February typically has 28 days, the upper limit for reviewer rest time does not exceed 28 days, with the interval set at [15,25] days in 5-day steps.

The number of researchers in most disciplines falls within the 20,000-80,000 range. Lotka parameters represent a disciplinary field, with values set at 2-4 in 0.25 steps to cover a broad range of disciplines and improve simulation universality. The rejection rate interval is set at [10%,20%] in 5% steps. The review qualification ratio interval is [50%,80%] in 15% steps to ensure reviewers possess necessary professional qualifications.

The constraint condition for setting Lotka parameter combinations is that the sum of percentages of authors with different paper counts equals 1. Using the generalized Lotka distribution formula f(x) = C/x^n, where f(x) is the proportion of authors writing x papers, parameter C is calculated based on this normalization constraint. The proportion of authors writing 1, 2, 3, or 4 papers is then determined.

Monthly paper upload volume fluctuates around 8% per month ($±$2%), assuming relatively uniform submissions throughout 12 months. Review completion time follows a normal distribution within the 10-60 day interval.

2.4 Experimental Design

Response surface analysis obtains dependent variables through experimental design and uses polynomial regression to derive quantitative relationships between system independent variables and response characteristics. Common non-full factorial experimental designs for response surface analysis include central composite design and Box-Behnken design (BBD). A major advantage of BBD is that experimental parameter values do not exceed the set range, making it the chosen method here.

Using Design-Expert software for BBD, we selected the four key parameters—reviewer rest time, rejection rate, number of researchers, and review qualification ratio—as independent variables, each with three levels coded as -1, 0, and +1 representing low, medium, and high levels. The three performance indicators—CR, TBD, and A_r_{time}—serve as dependent variables. Independent variable data were normalized using dimensionless scaling.

A separate BBD table was designed for each Lotka parameter value. Each combination in the BBD table underwent three repeated experiments. Using R language programming, each combination was run 50 times for 15 Lotka parameter values, with the summary() and mean() functions calculating average performance indicators. Response surface analysis was then performed on the

BBD sampling data to obtain quantitative relationships between performance indicators and key parameters.

The regression equations relating CR values to the four key parameters under different Lotka parameter values are detailed in Table 4. Model fitting statistics in Table 5 show that for all models, the lack-of-fit Pr values exceed 0.05, while R^2 and adjusted R^2 values exceed 0.99, indicating high consistency between actual measured values and predicted values. The adjusted R^2 and predicted R^2 values are close, with adequate precision far exceeding 4 and coefficient of variation (C.V.) below 3%, demonstrating high experimental reliability. Variance inflation factor (VIF) values are all below 1.414, indicating no collinearity issues.

Analysis reveals that: (1) Among the three performance indicators, CR shows the greatest variation with factor changes, while TBD and A_r_{time} fluctuate less. (2) The absolute value of the review qualification ratio variable coefficient is several times that of the other three independent variables, indicating its contribution to CR performance far exceeds others. Rest time ranks second in importance, while researcher number and rejection rate have insignificant effects. (3) All experimental combinations yield TBD values greater than 80%, indicating uneven reviewer task distribution in self-organizing peer review. (4) A_r_{time} values fall within [33,35] days, significantly faster than the 2-3 months typical of journal peer review.

3.3 Key Parameter Interactions

Since rejection rate and researcher number are difficult for the National Preprint Platform management agency to control, we focus discussion on interactions between rest time and review qualification ratio. Response surface and contour plots visually describe parameter interactions. According to Figure 1, as rest time decreases and review qualification ratio increases, CR values increase. The response surface slope is relatively steep with slightly curved contours, indicating a significant interaction effect. Rest time and review qualification ratio substantially influence self-organizing peer review performance, with review qualification ratio being far more important than the other three parameters.

[Figure 1: see original paper]

4 Application Example: Optimization Design of Key Parameters for Self-Organizing Peer Review

The simulation equations provide numerical experimental evidence for the National Preprint Platform to adopt self-organizing peer review for ensuring paper quality and offer quantitative support for management decisions. In practice, the platform management agency can optimize design based on the number of submitting authors in a discipline and empirical rejection rates (or real rejection rate data obtained after operation).

Taking a discipline where the author-paper distribution follows Lotka's law with parameter value 2 as an example, the quantitative equation from Table 3 is:

$y_{11} = 62.38 - 1.1x_1 + 0.21x_1^2 + 0.012x_2 - 0.046x_2 + 0.072x_3 - 0.047x_4 + 14.71x_4 - 0.31x_1x_4 + 0.053x_2x_3 + 0.033x_2x_4 - 0.003x_1x_2 + 0.066x_1x_3 - 0.12x_3x_4$

If the platform management expects self-organizing peer review performance with CR $\geq$ 75%, multiple parameter value combinations can achieve this. Three scenarios are provided for reference:

1. If author number falls in [0,20,000] and rejection rate in [10%,15%], set rest time at 20 days and review qualification ratio at 80%, yielding CR in [77.24%,77.32%].
2. If author number falls in [20,000,40,000] and rejection rate in [15%,20%], set rest time at 15 days and review qualification ratio at 80%, yielding CR in [78.32%,78.34%].
3. If author number falls in [40,000,80,000] and rejection rate in [15%,20%], set rest time at 25 days and review qualification ratio at 80%, yielding CR in [75.51%,75.56%].

For other Lotka parameter values, similar calculations can be performed using the corresponding quantitative equations.

5 Conclusion

The main conclusions of this study are: (1) Review qualification ratio and reviewer rest time significantly impact self-organizing peer review performance, with review qualification ratio being far more important than the other three key parameters. (2) Researcher number has minimal impact on self-organizing peer review performance, with its variable coefficient absolute value being very small and approximately negligible. (3) Review qualification ratio and rest time are completely controllable by the National Preprint Platform management agency, while rejection rate and researcher number are not.

The contributions of this research to National Preprint Platform construction are: (1) The simulation provides numerical experimental evidence for adopting self-organizing peer review to ensure paper quality. (2) The obtained simulation equations offer quantitative support for platform management decision-making. It should be emphasized that due to limited computational resources, simulation accuracy could be improved. With adequate computational resources, more precise simulations can be conducted following the methods and parameters proposed in this paper.

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Note: Figure translations are in progress. See original paper for figures.