Are Disruptive Patents Less Likely to be Granted? Analyzing Scientific Gatekeeping with USPTO Patent Data (2004-2018)

Lihan Yan[1,2], Haochuan Cui[3,*] and Cheng-Jun Wang[1,2,*]

[1]Laboratory of Data Intelligence and Interdisciplinary Innovation, Nanjing University, Nanjing, 210023, China
[2]School of Journalism and Communication, Nanjing University, Nanjing, 210023, China
[3]School of Information Management, Nanjing University, Nanjing, 210023, China

Abstract

How does scientific gatekeeping in the patent examination system affect disruptive innovation? Although the patent system was established to safeguard innovation, previous research implies that disruptive innovation faces stronger challenges in gaining recognition. To open the black box of scientific gatekeeping, we analyze the dataset of the US Patent and Trademark Office between 2004 and 2018. Findings show that disruptive innovation is detrimental to patent approval, whereas examiner workload and work experience can enhance it. Moreover, examiner workload mitigates the negative impact of disruptive innovation on patent approval, while examiner work experience can amplify the impact of examiner workload on patent approval. This study contributes to the science of science by unveiling the seemingly contradictory gatekeeping logic of patent examiners. The implications help design a more innovation- friendly incentive mechanism for scientific gatekeeping.

Keywords

disruption innovation, examiner workload, examiner work experience, scientific gatekeeping

1. Introduction

Despite the patent examination system intended to safeguard innovation, it may pose formidable hurdles for disruptive innovations striving for acknowledgment. Designed by the government to protect innovative technologies [1], an important task for patent examiners is to identify innovative patent applications based on prior submissions [1]. Serving as impartial third parties, patent examiners are expected to offer comparatively objective assessments of the quality of patents. However, disruptive innovation faces many challenges in terms of its scientific impact and acceptance. Kuhn posits that innovation is a form of anomaly, and truly understanding such groundbreaking works, which challenge established paradigms, often demands a substantial amount of time [2]. Prior research shows that disruptive innovation is risky and hard to pay off [3, 4, 5]. Noh and Lee, in their analysis of patents within the telecommunications field, suggest that disruptive innovations often struggle to capture the attention of examiners due to their significant deviation from existing technologies[6]. Thus, we formulate the key puzzlement of this study: does scientific gatekeeping within the patent examination system promote or suppress disruptive innovation?

We draw our research on the theories of scientific gatekeeping, analyzing 4.5 million patents (2006–2013) of United States Patent and Trademark Office's (USPTO) dataset, and build a citation network according to the dataset with network analysis methods. We define disruption innovation as a leap or break with the traditional knowledge structure [5], and quantify disruptive innovation by the CD index five years after the publication year of each patent[7]. To explore the bias in the patent approval process, we focus on two key characteristics of patent examiners, namely workload and work experience. Then, we use mixed effect models and propensity score weighting (PSW) to construct regression models and test the hypotheses.

We claim that disruptive innovation has a negative impact on the patent approval, and examiner workload can reduce the impact of disruptive innovation on the patent approval. Examiner workload and Examiner work experience both have a positive impact on the patent approval, and examiner work experience can amplify the effect of examiner workload on the patent approval. Additionally, granted patents means more patent citations, which helps knowledge flow and technology spillover. This study contributes to the science of science by unveiling the seemingly contradictory gatekeeping logic of patent examiners towards disruptive innovations.

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*Corresponding author.
602022110022@smail.nju.edu.cn (L. Yan); hcui94@hotmail.com (H. Cui); wangchj@126.com (C. Wang)
YAN-Lihan.github.io (L. Yan)
0000-0003-3057-1763 (L. Yan); 0000-0001-9686-4265 (H. Cui); 0000-0002-8356-8528 (C. Wang)

2. Literature Review

2.1. Disruptive Innovation and Patent Approval

Disruptive innovation indicates a leap or a break with the traditional knowledge structure [5], which is quite essential in the progress of science. However, normal science tends to explain existing problems and expand based on traditional knowledge rather than breaking out of the existing knowledge framework for innovation (Kuhn, 1962). The same thing happens with patents even patents are used to protect innovation by the government. A patent that introduces a groundbreaking and disruptive innovative idea may struggle to attract attention because it is significantly different from existing technologies [6]. Moreover, some patents with a high degree of disruptive innovation may be accompanied by technical boundary spanning [6], which requires the examiner to do more back-and-forth work with the patent office, increasing the difficulty of examination and adversely affecting the granting result [8]. Therefore, we propose the hypothesis as follows:

H1: Disruptive innovation has a negative effect on patent approval.

2.2. Patent Examiner and Patent Approval

With the increasing workload, patent examiners are required to review a greater number of patent applications within a fixed timeframe, which affects the patent granted and patent quality. Rejecting a patent takes more time than accepting one [9, 10]. If examiners do not have sufficient time to thoroughly review all relevant prior art for each application to find if they meet the novelty, then granting patents to applications that should have been rejected is more likely to occur [11, 12]. Moreover, the experience of examiners inevitably varies significantly at a specific point in time or concerning a particular group of patents, influencing the quality and outcome of patents granted [13]. The increase in the examiner's work experience will make them inclined to grant a patent. Mann suggests that an increase in work experience may instigate a "burnout" effect, and result in an escalated workload, which links to a higher rate of patents granted [14]. Therefore, we propose the following hypothesis:

H2: Examiner workload ***(a)*** and examiner work experience ***(b)*** has a positive effect on patent approval.

As the experience and workload of an examiner increases, they are more inclined to grant patents [15], which may consequently result in a relatively higher approval rate for patents involving disruptive innovation. If an experienced examiner conducts the review, their relatively reduced focus on existing technology [15] might lead to a more lenient assessment of patents involving disruptive innovation. Additionally, patents featuring disruptive innovation often involve interdisciplinary aspects, which might not entirely conform to the anticipated knowledge framework. This implies that reviewing patents involving disruptive innovation is relatively less challenging for these experienced examiners. Moreover, rejecting disruptive patents requires finding specific reasons, such as a significant gap from the current technology [6], which needs more time to do this kind of work. However, the time constraints caused by workload make it relatively challenging for examiners to achieve this. Therefore, we propose the hypothesis as follows:

H3: Examiner work Experience ***(a)*** and examiner workload ***(b)*** can reduce the negative impact of disruptive innovation on patent approval.

The accumulation of work experience enables examiners to gradually form personalized work routines, which diminishes their susceptibility to workload. Accumulated work experience enables patent examiners to conduct examinations with greater efficacy and efficiency, empowering them to better manage time constraints[19]. On the contrary, less experienced examiners are more prone to relying heavily on prior patents in their patent examination process [15], which amplifies the positive effect of workload on grant approval. In all, examiners' work experience mitigates the impact of their workload on patent approval. Thus, we propose the hypothesis as follows:

H4: Examiner work experience can mitigate the positive effect of examiner workload on patent approval.

3. Method

3.1. Data

We use the USPTO Patent dataset to obtain the basic information about patents (2004-2018). In order to calculate the work experience of examiners and CD5 accurately, we analyze 200 thousand patents from 2006 to 2013 after data merging and cleaning.

3.2. Measures

3.2.1. Dependent variables

Patent Approval. Patent Approval is a dummy variable that refers to the status of the given patent whether be granted or not. This variable takes the value 1 if the patent is granted and 0 if it is rejected.

3.2.2. Independent variables

Disruptive Innovation. Following the tradition of prior research [17, 18], we calculate the D-score of disruption for each patent as follows:

Table 1
Correlation Matrix of Key Variables

	Disruptive Innovation	Patent Approval	Patent Citations	Examiner Workload	Examiner Work Experience
Disruptive Innovation					
Patent Approval	-0.038***				
Patent Citations	-0.102***	0.035***			
Examiner Workload	-0.057***	0.229 ***	0.040***		
Examiner Work Experience	-0.049***	0.042***	-0.080***	0.205***	

Note:*p < 0.1; **p < 0.05; ***p < 0.001

$$D = \frac{n_i - n_j}{n_i + n_j + n_k}, \quad (1)$$

where n_i is the number of subsequent papers that cites the focal paper, n_j is the number of subsequent papers that cite both the focal paper and its references, and n_k is the number of subsequent papers that only cites the focal paper's references. However, the measure of disruption D tends to be underestimated in the first few years (Lin et al., 2022). Therefore, we calculate disruptive innovation based on citations of the focal paper over a 5-year time window (CD5). Because the distribution of disruption is also highly skewed, we use the CD5 percentile (M = 0.59, SD = 0.35) to measure the disruptive innovation of the patent.

Examiner Workload. Examiner workload refers to how much of the burden of other patents is assigned to the examiner when they evaluate the focal patent. We weighted patents in the period between the filing date of the focus patent and the date of grant or rejection to make the calculation more accurate based on the work of Funk and Owen-Smith [17].

Examiner Work Experience. Examiner work experience is the number of years the examiner has worked for USPTO. We exclude the examiner appearing in the first 2 years of the dataset to calculate more accurately (M = 3.09, SD = 1.82).

4. Findings

The key puzzlement of this research focuses on the relationship between Disruptive Innovation, Patent Granted, and Patent Examiners. To begin, we report the correlation matrix of the key variables in **Table 1**.

We make use of mixed effect model to test research hypotheses 1-4 (see **Table 2**), which is related to the relationship between disruptive innovation, examiner work experience, examiner workload, and patent granted. As **Table 2** shows, the results indicate a negative impact of disruptive innovation on the patent granted, that is, the higher the disruptive potential of a patent, the greater the difficulty in obtaining a grant. Therefore, ***H1*** is well supported.

According to the results of Model 2-4 in **Table 2**, both examiner work experience and examiner workload have a positive impact on the patent granted. In other words, the shorter the tenure of examiners and the greater their workload, the likelihood of patents being accepted tends to increase. Therefore, ***H2(a)*** and ***H2(b)*** are well supported.

As Model 5 shows in **Table 2**, firstly, the moderation effect of Examiner Work Experience is not significant. Thus ***H3(a)*** is rejected. Secondly, Examiner Workload has a moderate effect on the relationship between Disruptive Innovation and Patent Approval, reducing the negative impact of Disruptive Innovation on the Patent Approval (as shown in **Figure** 1). Furthermore, the result of simple slope analysis reveals that when the values of workload are at -1 SD, Mean, and +1 SD, their slopes are -0.40 (t = -23.78, p < 0.001), -0.22 (t = -23.78, p < 0.001), and -0.04 (t = -23.78, p = 0.16), respectively. It means that for examiners with more work, the probability of rejecting a disruptive patent is relatively smaller. Therefore, ***H3(b)*** is supported. Thirdly, Examiner Work Experience moderates the effect of Examiner Workload on Patent Granted. The result of simple slope analysis reveals that when the values of workload are at -1 SD, Mean, and +1 SD, their slopes are 0.86 (t = 71.48, p < 0.001), 1.03 (t = 105.06, p < 0.001), and 1.20 (t = 82.84, p < 0.001), respectively. When the examiner workload is less than approximately 4.5, higher examiner work experience is associated with a lower probability of patent approval at the same workload level. Therefore, ***H4*** is only partially supported.

5. Conclusion

In summary, this study aims to elucidate the relationship between disruptive innovation, patent examiners, and granted patents, investigating factors influencing patent approval including disruptive innovation, exam-

Table 2
Mixed Effect Model and Interaction Effect on Patent Approval

	Patent Approval				
	Model 1	Model 2	Model 3	Model 4	Model 5
Disruptive Innovation	-0.400***			-0.372***	-1.828***
Examiner Workload		1.150***		1.527***	1.232***
Examiner Work Experience			0.090***	0.083***	-0.068***
Disruptive Innovation * Examiner Workload				0.322***	
Disruptive Innovation * Examiner Work Experience					-0.014
Examiner Workload * Examiner Work Experience					0.034***
Control variables	Yes	Yes	Yes	Yes	Yes
Team Size	Yes	Yes	Yes	Yes	Yes
References	Yes	Yes	Yes	Yes	Yes
Number of Labels	Yes	Yes	Yes	Yes	Yes
IPCR Labels	Yes	Yes	Yes	Yes	Yes
Year	Yes	Yes	No	No	No
Country	Yes	Yes	Yes	Yes	Yes
Random effect					
Examiner ID	Yes	Yes	Yes	Yes	Yes
Constant	0.188	-5.958***	-0.316***	-6.619***	-5.288***
Log Likelihood	-534,028.700	-518,339.500	-125,823.100	-119,516.800	-119,452.800
Akaike Inf. Crit.	1,068,117.000	1,036,739.000	251,692.200	239,083.700	238,961.700
Bayesian Inf. Crit.	1,068,471.000	1,037,092.000	251,927.600	239,339.600	239,248.200

Note: * p < 0.1; ** p < 0.05; *** p < 0.001

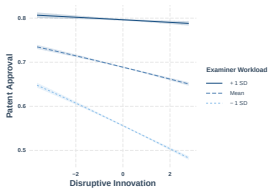

Figure 1: The Moderation Effect of Examiner Workload on Patent Approval

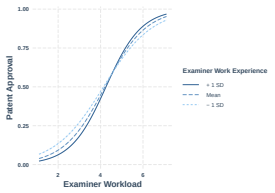

Figure 2: The Moderation Effect of Examiner Work Experience on Patent Approval

iner workload, and experience, while also exploring the impact of granted patents on citations. This study has significant theoretical and policy implications. First, we provide additional evidence from the gatekeeping perspective that disruptive innovation faces difficulties in gaining acceptance in the scientific field [2]. Second, we explore the bias of examiners from the aspects of workload and work experience, thereby shedding light on the black box of the gatekeeping process by contrasting granted and rejected patents. Third, the mechanisms by which innovation is either fostered or hindered during the gatekeeping process help better understand and enhance the existing patent examination system's ability to safeguard innovation.

We acknowledge the limitations of this study, which provide some insights and directions for future research. First, we lack examination opinion data that detail the reasons for patent rejections. If specific examination opinions are available, it would enable exploration of more precise gatekeeping mechanisms. Second, when measuring the impact of a patent, we have only considered patent citations and have overlooked the influence of academic papers. Third, demographic factors of patent examiners e.g., gender and age) which could influence their decision-making processes and potential biases, are not included in the analysis.

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