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Patent quality and patentability requirements: Evidence from the third amendment to the Chinese Patent Law

Teng Huang^{a, b}, Cheryl Xiaoning Long^{c, d, *}

^a College of Economics and Management, Northwest A&F University, Yangling, Shaanxi, China

^b Xinjiang Research Institute of Agriculture in Arid Area, Urumqi, Xinjiang, China

^c Xiamen University, Xiamen, Fujian, China

^d Xiamen University Malaysia, Sepang, Malaysia

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ABSTRACT

This paper provides novel empirical evidence that stricter patentability requirements improve patent quality based on a quasi-natural experiment—the third amendment to the Chinese Patent Law. The results from difference-in-differences estimation show invention patents meeting absolute novelty are more likely to be cited internationally, renewed, and invalidated less frequently than those with relative novelty. We identify three specific mechanisms through which the stricter patentability requirement exerts its impact on patent quality, including the screening-out effect, where stricter patent approval standards weed out low-quality applications during substantive examination, the self-selection effect, where stricter patentability requirements motivate applicants to select higher-quality inventions in response to the lower probability of patent approval, and the foreign-inflow effect, where the higher standards create more effective patent protection, which attracts more overseas applicants and higher-quality overseas technologies. These findings support the relationship between patentability standards and quality and have implications for patent law reforms in developing countries.

1. I. Introduction

Intellectual property rights (IPR) are key institutions shaping the trajectory of innovation, which is a main driver of sustainable economic growth. Among these, the patent system plays a pivotal role by rewarding inventors with temporary exclusivity while promoting knowledge disclosure and diffusion (de Rassenfosse & Jaffe, 2018; Lamoreaux & Sokoloff, 2001; Schankerman & Schuett, 2022). When functioning effectively, the institution of patents strikes a balance between private innovation incentives and social welfare. Yet in practice, concerns have mounted over the growing prevalence of low-quality patents, which are granted to innovation outputs that are incremental, trivial, or even unoriginal (de Rassenfosse, Griffiths, Jaffe, & Webster, 2021). Such patents not only misallocate protection resources away from genuine innovators but also generate welfare losses through excessive litigation, fragmented ownership, and reduced R&D incentives (Barton, 2000; Farrell & Shapiro, 2008; Lemley & Shapiro, 2005).

Recognizing the challenges posed by declining patent quality over time, many countries have undertaken institutional reforms to strengthen examination standards and restore innovation incentives. For example, the U.S. Patent and Trademark Office (USPTO) has dedicated an Office of Patent Quality Assurance and established an ongoing online “patent quality chat” in 2015 to help regularly

* Corresponding author at: Xiamen University Malaysia, Jalan Sunsuria, Bandar Sunsuria, 43900 Sepang, Selangor Darul Ehsan, Malaysid
E-mail address: cxlong@xmu.edu.cn (C.X. Long).

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conduct public dialogues on patent quality (de Rassenfosse et al., 2021). Likewise, South Korea have adjusted patentability and enforcement standards to encourage technological upgrading while curbing strategic patenting and imitation-based growth (Erstling & Strom, 2009). Similar reform efforts have also emerged in developing economies seeking to balance innovation incentives with quality assurance, including India's 2005 Patent (Amendment) Act, which significantly tightened patenting requirement and raised the examination standard for pharmaceutical inventions, thereby stimulating R&D investment but also provoking debates about access and industrial concentration (Mueller, 2006; Singh, 2022). These cross-country experiences underscore the broader global shift toward reinforcing patent quality as a foundation for sustainable innovation.

As the largest transition economy experiencing rapid expansion in patent filings but continued declining average quality (Long & Wang, 2019), China's experiences with its evolving patent system offer a particularly good setting for studying the effects of such reforms. Before the Third Amendment to the *Chinese Patent Law* in 2009, China's *relative novelty* standard allowed the granting of patents to technologies not previously disclosed in China, even if already public abroad, implying relatively lower patentability thresholds. This created opportunities for speculative filings and technological duplication on one hand, and weak protection for genuine innovations on the other. To address this issue, the China National Intellectual Property Administration (CNIPA) replaced *relative novelty* with *absolute novelty* in the Third Amendment of 2009, thus aligning the prior-art standard with international norms and raising the threshold for patent approval.¹

This paper exploits the 2009 amendment as a quasi-natural experiment to identify the impact of stricter patentability standards on patent quality. Using a Difference-in-Differences (DID) framework and constructing treatment and control groups based on technology field exposure to the amendment, we examine both the overall quality effects and the underlying mechanisms. The main findings are as follows.

Firstly, the stricter approval standards significantly improved patent quality in China. Patents granted after the reform were more likely to be cited internationally, maintained for longer periods of time, and less likely to be invalidated. These findings remain robust across multiple specifications, indicating that the Third Amendment to the *Chinese Patent Law* has fulfilled the task of "improving patent quality and enhancing the stability of patent rights".² Secondly, we identify three mechanisms through which higher patentability standards improve quality: by screening out the inferior inventions during the substantive examination process (i.e., *screening-out* effect), by motivating applicants to select technical innovations of higher quality for patent application (i.e., *self-selection* effect),³ and by attracting more overseas innovative technologies of high quality to apply for patent protection in China (i.e., *foreign-inflow* effect).

This study makes the following threefold contributions to the literature: First, it provides large-scale causal evidence on the effects of the 2009 Third Amendment to the Chinese Patent Law on patent quality. Prior studies have argued that the amendment, particularly the shift of the novelty standard from relative to absolute, would reduce "garbage patents" (Bai, 2009; Yang & Yen, 2009). However, these discussions were largely theoretical and need to be backed up by rigorous empirical verification. Using the database of over 1.7 million invention patent applications and applying the DID identification strategy, we show that stricter examination standards have significantly enhanced patent quality, underscoring the effectiveness of standards tightening in fostering innovation.

Second, we shed light on how exactly higher approval standards shape innovation outcomes. Beyond confirming the existence of the widely expected *screening-out* effect, we uncover two other important mechanisms: *self-selection* and *foreign-inflow*. We further refine the mechanism analysis by identifying the main drivers of the screening-out and self-selection effects. By exploiting heterogeneity across patent agents and applicant types (firms, universities, and individuals), we find that the *screening-out* effect mainly operates through applications filed by agencies and university inventors, whose inventions exhibit greater quality dispersion. In contrast, the *self-selection* effect is primarily driven by firms and professional agencies that became more selective in applying for patents meeting the stricter standards. These results provide a behaviorally grounded explanation of how heterogeneous innovators adapt to institutional reforms, enriching the micro-level understanding of policy impacts on innovation quality.

Third, our study not only provides new empirical evidence on how strengthening patentability criteria influences innovation quality in developing and transition economies, but it also contributes to the more general literature on how differences across jurisdictions impact the effectiveness of policies that are particular to a region. The choice of patentability standards lower than the rest of the world has led to negative impact on the quality of Chinese patents, thus highlighting the significance of internationally unified standards for facilitating knowledge exchange, technological upgrading, and sustained growth. By linking a developing economy's institutional reform to measurable improvements in innovation quality, our findings reveal the institutional foundations of patent quality enhancement in China and highlight how globalization and policy convergence can jointly foster innovation capacity.

The remainder of the paper proceeds as follows: Section 2 presents a literature review, discusses the institutional background, and outlines the theoretical analysis; Section 3 and Section 4 presents the empirical research design and the estimation results, respectively; while in Section 5, mechanism examinations are conducted, respectively. Section 6 offers a brief conclusion and some policy suggestions.

¹ As required by the patent system, technological innovations applying for invention patent protection should satisfy the 'patentability' criteria, i.e., to be novel, non-obvious and useful. When determining whether an innovation meets the novelty and the non-obviousness criteria for patentability, a key concept is prior art, defined as anything available to the public that might be relevant to the innovation's patent claims. Specifically, for the current innovation to be novel, it cannot fall into the category of 'prior art'; and for it to be non-obvious, it has to exhibit sufficient differences and significant progress from the 'prior art'. Yet, there are substantial differences across jurisdictions in how prior art is defined.

² As summarized on China Intellectual Property Annual Conference on September 5, 2011, by Song Jianhua, Director of the Department of Treaty and Law, China National Intellectual Property Administration, the Patent Law was amended for four purposes, and one of them was to 'raise stricter patent approval conditions, improve patent quality and boost stability of patent rights.'

³ Alternatively, inventors may simply omit lower-quality innovations from their patent application process.

2. Literature review, institutional background and theoretical analysis

In this section, we give a brief review of the relevant literature, a discussion of the institutional background of China's patent system and innovation policies, as well as an outline of the theoretical analysis, which will help frame the empirical analysis in the later sections.

2.1. Literature review

A large body of research investigates how the design and operation of patent systems influence patent quality, focusing primarily on developed economies such as the United States. These studies examine the effects of three key components: patent fees, judicial practices, and examination procedures.

Regarding patent fees, [de Rassenfosse and Jaffe \(2018\)](#) exploit the substantial increase in application and maintenance fees since the enforcement of the *1982 Amendment to Patent Law* in the U.S. as a quasi-natural experiment, finding that the higher fees can eliminate 10 % of patents with the lowest quality, and the patent quality improvement is mainly attributed to that in large-scale enterprises. [Schankerman and Schuett \(2022\)](#) further show, through a signaling game model, that appropriate fees structures can effectively screen out poor-quality patents.

In terms of judicial practices, [Lichtman and Lemley \(2007\)](#) advocate lowering the presumption of validity and the standard for patent invalidation in the proposed legislation, while [Schankerman and Schuett \(2022\)](#) point out that lowering patent litigation fees can enhance courts' corrective function, although the courts alone cannot fully ensure patents quality.

For patent examination procedures, [de Rassenfosse et al. \(2021\)](#) identify weak procedures as a major source of low-quality patents. They find that poor efficiency and improper standards allow between 65 % and 85 % of granted U.S. patents to be later invalidated, with only 30 % of poor-quality patents screened out during the examination process. To improve examination efficiency, [Noveck \(2006\)](#) suggests incorporating peer review, [Dreyfuss \(2008\)](#) and [Eisenberg \(2004\)](#) call for higher non-obviousness standards, and [Boldrin and Levine \(2008\)](#) argue that patented technology must conform to certain more rigorous conditions such as "convincing novelty, extremely high R&D cost of innovation but a low cost of being imitated, and extremely inflexible product demands". Additionally, [Schankerman and Schuett \(2022\)](#) propose that patent rights should only be granted to technical inventions whose inventors fail to benefit from them in the absence of patent protection, arguing that granting rights otherwise increases social costs.

While these studies have substantially advanced our understanding of patent quality determinants, they remain largely centered on advanced economies and their institutional settings. In contrast, developing countries, which are increasingly central to global innovation, have received limited attention, despite facing unique challenges stemming from marked differences in institutional capacities and industrial structures. For example, India's 2005 Patent (Amendment) Act, which reintroduced pharmaceutical product patents with stricter patentability to provide stronger intellectual property protection ([Mueller, 2006](#)), encouraged R&D investment and export upgrading but also raised concerns about rising drug prices and market concentration, underscoring the delicate balance between innovation incentives and social welfare ([Basheer, 2005](#); [Singh, 2022](#)). Beyond the tension between patent strength and social welfare, other structural and institutional challenges also complicate the function of the patent system in the developing world. In economies such as Pakistan, Argentina, and Colombia, weak IP enforcement often limits the strategic use of patent information by firms, especially because only a small fraction of local industry operates near the technological frontier, thus limiting the direct relevance of high-quality patents ([Crespi & Zuniga, 2012](#); [Wadho & Chaudhry, 2018](#)). Collectively, these varied experiences highlight the fact that the actual performance and effectiveness of patent system are highly context-dependent. Such evidence underscores the urgent need for rigorous empirical studies on emerging economies to fully understand how the design and operation of patent systems should be structured to maximize their function and intellectual property effectiveness within those specific contexts.

To address this gap, we focus on China, the largest developing economy, to explore the factors influencing its patent system. Prior research on China has mainly explored the effects of various policy factors on patenting behaviors, such as market competition ([Zhang, Chen, Yang, & Lin, 2015](#)), intellectual property right protection ([Feng, Zheng, Wen, & Zhang, 2020](#)), patent promotion policies ([Long & Wang, 2015](#); [Long & Wang, 2019](#); [Zhang et al., 2015](#)), and environmental regulations ([Tao, Zhao, & Zhou, 2021](#)). However, few studies have investigated how institutional features of the patent system itself affect patent quality. In particular, the existing literature on China's recent 'patent bubble' has largely left out how the various features of the patent examination system impact patent quality and the related application behaviors, including patent approval standards. Although [Hu and Jefferson \(2009\)](#) provide an early quantitative evaluation of patent law reforms on China's innovation outcomes, no study to date has offered direct empirical evidence linking patentability thresholds to patent quality.

Our study attempts to fill this gap by providing a quantitative study of the Third Amendment to the *Patent Law of China* in 2009. Specifically, we empirically examine the effects of the patentability criterion change from relative novelty to absolute novelty on patent quality, as well as the mechanisms through which changes occur. In addition to contributing to the innovation literature in China, we also hope to extend the literature on patent system design beyond developed economies and contribute to a growing body of evidence on the institutional foundations of innovation quality in the context of developing and transition economies.

2.2. Institutional background: the Third Amendment to the Chinese Patent Law and the related debate

The original *Patent Law of the People's Republic of China* was not enacted till March 1984, and its enforcement began in April 1985. The first amendment to the law was made in September 1992, which granted patent rights to pharmaceuticals, chemical substances and food items, fulfilling commitments made in the *People's Republic of China-United States of America: Memorandum of Understanding*

on the Protection of Intellectual Property. In August 2000, the second amendment was completed, which reconciled the differences between China's patent regulations and the related rules of the TRIPS Agreement to help promote China's accession to the WTO. Clearly, while these two earlier amendments brought about further compatibility of the *Chinese Patent Law* with international standards, their main objective was to satisfy outside demands.⁴

The Third Amendment to the patent law, completed in December 2008 and implemented in October 2009, is the focus of this paper. In comparison with the two previous amendments, the Third Amendment is more of a self-motivated initiative than a response to external pressure, as an important decision of "improving China's patent system" based on "innate needs of socio-economic development and new situations of international rule adjustment" (Wang, 2009). In the minds of Chinese decision-makers, the rapid growth of global economy and increasing international competition had made intellectual property a strategic resource and a core element of national competitiveness by then. Thus, China needed to improve its capability to create and apply intellectual property, with the aim to enhance the national core competitiveness and build an innovation-based nation. This realization, coupled by awareness of changes in international intellectual property rules and technological development tendencies, led China to reexamine the stipulations in its *Patent Law*, and then to initiate the Third Amendment and the detailed implementation rules. The two most prominent changes focus on raising patent approval standards and reinforcing patent right protection (Shao, 2018).

A key substantive change in the Third Amendment was the redefinition of prior art and the formal adoption of an absolute (global) novelty standard. Before 2009, China applied a relative-novelty rule: an invention not disclosed publicly in China could be patentable even when it had been disclosed or commercially used abroad. This relative standard implies a lower effective threshold for patentability and created two major distortions. First, it weakened incentives for genuine innovation by allowing domestic "speculators" to obtain exclusive rights over technologies already public or commercialized outside of China. Second, this arrangement hindered fair competition and impaired IP protection for foreign innovators, consequently limiting the diffusion and application of established overseas technologies within China.

To address these problems, the 2009 Amendment redefined "prior art" to include technologies already known among the public in China or in foreign countries (including publications, sales, commercial use, and published patents). By extending the scope of "prior art," China thus adopted the absolute novelty standard (or global novelty) in determining novelty and non-obviousness. Under this new standard, technology that had been publicly used abroad, for example, could no longer acquire patent protection in China.⁵ This change unequivocally toughened the criteria for novelty and non-obviousness during the substantive examination stage, significantly raising the patentability threshold since 2009.

Scholars, however, have offered mixed assessments of whether stricter novelty standards improve patent quality. Hu et al. (2009), argue that simply tightening the novelty test does not necessarily raise quality: the novelty is a narrow legal criterion, and examiners may still fail to discover technologies that have been publicly used but not published. Other critics worry that better-resourced foreign firms will exploit advantages in evidence collection and portfolio analysis to invalidate Chinese patentees' rights. Still others emphasize the positive effects of the Third Amendment, arguing that higher patentability standards help encourage independent innovation, protect technologies of different origins, promote diffusion and adoption of patented technology, and enhance corporate performance (Xu & Wei, 2020). One explanation for the disagreement among existing research is the qualitative nature of these studies and the consequent weakness in establishing causality. The current paper addresses that gap with a large-scale quantitative analysis designed to identify the causal effects of raising patentability standards. Using detailed patent data and a quasi-experimental DID design, we quantify how the change in the prior-art definition affected patent outcomes in China and investigate the channels that drive those effects.

3. Theoretical analysis

We describe a stylized model in this section to illustrate the various mechanisms through which a tougher standard for patent approval can lead to improvement of patent quality. As shown in Fig. 1, the quality of a technological innovation applying for a patent is assumed to follow a normal distribution, which initially corresponds to curve N_0 , and a minimum quality level is required for granting a patent, which is denoted by a dotted vertical line in the figure. In other words, when the quality of a technology is to the right of the dotted line, the corresponding patent application will pass the substantive examination and get an invention patent granted by an examiner.

Before the 2009 amendment, the threshold quality level corresponding to the *relative novelty* criterion is given by S_0 , which, after the adoption of the *absolute novelty* criterion in the Third Amendment, is elevated to S_1 . Thus, for patent applications with the quality distribution given by N_0 , those with quality between S_0 and S_1 would have been granted patents under the old law would be rejected according to the 2009 Amendment. Alternatively, some of the granted patents with inferior quality would be screened out because of the stricter patent approval standard, resulting in higher average quality of patents approved in later years. We refer to this quality enhancement effect of the new law as the *screening-out* effect, which can be observed by comparing *patents granted* before and after the 2009 Amendment.

⁴ For more details, see the *People's Republic of China-United States of America: Memorandum of Understanding on the Protection of Intellectual Property* signed in 1992 and requirements of the *TRIPS Agreement*. To comply with the TRIPS Agreement, the second amendments included definition of patent right, non-infringing acts, damage calculation, and preliminary injunction, etc. (Lin, Wood, & Jang, 2004).

⁵ See the speech made at the 2011 China Intellectual Property Annual Conference (Sept. 5, 2011) by Mr. Song Jianhua, Director of the Department of Treaty and Law, China National Intellectual Property Administration, the original text of which was published in the Peoples Network on September 7, 2011 (http://old.cnipr.com/focus/sdbd/201109/t20110905_136715.html), accessed on July 29, 2020).

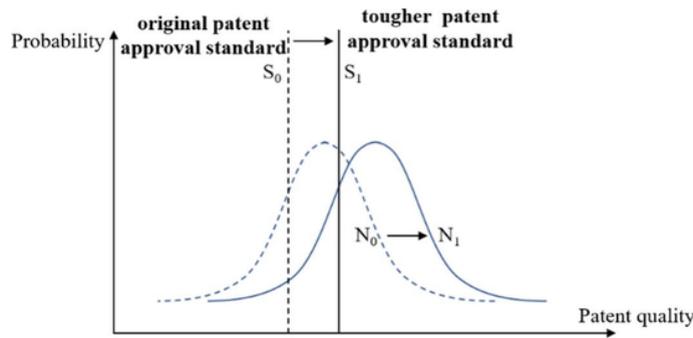


Fig. 1. Impact of tougher patent approval standards on patent quality.

The 2009 Amendment, however, can impact patent quality in China through other channels. While the *screening-out* effect is demonstrated in Fig. 1 via a movement of the threshold quality from S_0 to S_1 along the same quality distribution curve N_0 , the quality distribution itself may switch in response to the approval standard upgrade. For two reasons, the higher quality requirement for patent approval as embodied in the *absolute novelty* standard may lead to the general quality improvement of all patent applications, shown in Fig. 1 as the change of quality distribution curve from N_0 to N_1 .

Firstly, the stricter patent approval standard will send a signal to patent applicants that the probability of patent approval is now lower, as *absolute novelty* has become a necessary condition for granting the patent right. Given the substantial expenses involved in patent application, owners of technological innovations of inferior quality may find the benefit from patent application outweighed by the cost, thus choosing to not apply in the first place. This quality improvement effect of the new law can be referred to as the *self-selection* effect, which should show up in the quality difference between *patent applications* made before and after the 2009 amendment.

Secondly, the scope expansion of “prior art” in the 2009 amendment not only raises the patent approval standard in China, it also improves the country’s protection of patent rights by preventing patent infringement due to manufacture of foreign products not yet publicly known in China (Bai, 2009). As such, more effective protection is provided for truly innovative technologies, thus attracting more overseas inventors to submit patent applications in China. With the inflow of high-quality patent applications from overseas, the average quality of the total application pool is further improved. This third mechanism through which quality improvement materializes can be referred to as the *foreign-inflow* effect, which is also exhibited in the quality difference between *patent applications* made before and after the 2009 amendment.

In contrast to the *screening-out* effect where the technology quality distribution curve N_0 remains unchanged, both the *self-selection* effect and the *foreign-inflow* effect are reflected in the rightward movement of patent application quality distribution from N_0 to N_1 . In other words, while the former effect only implies quality improvement in approved patents after the amendment, the average quality of all patent applications will significantly improve if the enforcement of the 2009 amendment has led to the latter two effects. Furthermore, there are also different implications of the *self-selection* effect and the *foreign-inflow* effect. While the former effect applies to technological innovations applying for patent rights both by domestic residents and applicants from abroad, the latter effect is only applicable to patent applications filed by overseas inventors.

To summarize, stricter patent approval standards adopted in the Third Amendment to China’s patent law not only contribute to higher quality of patents granted by rejecting application requests for lower-quality technologies, the higher standards also help to improve the overall quality of all patent applications in China in two ways: (1) motivating inventors to self-select their innovative technologies for patent applications; and, (2) attracting more high-quality overseas technologies to apply for patent protection in China. Through these three mechanisms, the switch from *relative novelty* to *absolute novelty* in China’s 2009 amendment to its patent law can help improve patent quality of China in general.⁶

More specifically, the three mechanisms also have different theoretical implications as follows: According to the *screening-out* mechanism, the probability of application rejection is expected to increase significantly in the substantive examination stage after the 2009 amendment; with the *self-selection* mechanism at work, the overall quality of all patent applications (not just those eventually granted) is expected to improve after the enforcement of the 2009 amendment; whereas the *foreign-inflow* effect implies significantly higher proportion of patents applied by overseas inventors and higher quality of overseas inventions, as reflected in their higher global citation intensity (both cited and citing), for instance. We empirically examine these predictions in the following sections.

⁶ It should be noted that we assume constant overall quality of all innovative technologies invented in China in the above discussion. In other words, we abstract from the potential long-term effects of patent law amendments on innovation capacity improvement within China.

4. Empirical research design

4.1. Data sources

We rely on the patent database maintained by the China National Intellectual Property Administration (henceforth, the CNIPA database) to analyze the effects of stricter patent approval standards on patent quality. As the novelty standard change in the 2009 amendment only applies to the substantive examination stage that is not required for design patents and utility model patents, our study focuses exclusively on invention patents. We use the full sample of patent applications to explore the impact of standard changes on application quality, but the sub-sample of granted patents to analyze the effect on granted patent quality. To avoid the confounding effects from the second amendment (implemented between 2000 and 2001),⁷ we limit the sample to patent applications filed since 2002. We further restrict to patent applications filed before 2014 (included) due to data truncation and data availability, as the approval process for a typical invention patent takes up to five years and our database includes patent applications till up to 2019.

After dropping observations with missing information, we obtain over two million invention patent applications. For these patent applications, we have information on their application number, filing date, approval date, applicant, inventor, patent agent, forward citations and the International Patent Classification (IPC) code. We use the IPC system, the most commonly used international patent documentation classification and retrieval tool, to classify patents into different levels of technical fields, i.e., section, class and sub-class. Unlike [Tao et al. \(2021\)](#) and [Zhang and Zheng \(2018\)](#), who classify IPC at the class level, our main analysis classifies technical fields at the more granular sub-class level (IPC4), which yields 620 distinct technical fields, allowing for a more detailed examination of the data.

4.2. Treatment and control groups

To identify the influence of the 2009 patentability change using a difference-in-difference (DID) approach requires properly constructed treatment and control groups. Although the amendment raised approval criteria universally, its impact did vary significantly across technical fields, and we exploit this differential impact to define our groups. Specifically, we divide technical fields into two categories based on their proximity to the global technology frontier prior to the patentability change, referred to as “advanced” and “backward” fields henceforth. If a field was relatively advanced, its patent applications would already meet or be close to meeting global novelty standards. Thus, extending the scope of “prior art” from China to the world would only minimally affect these applications. In contrast, applications in a relatively backward field would experience a much greater impact because its novelty and non-obviousness would now be judged against the entire global innovation stock. Therefore, we can adopt the DID method to examine the causal effects of the patent law change on patent quality, by comparing the different effects on these two groups.

We define advanced fields (control group) and backward fields (treatment group) using the percentage of patents cited by international patents to proxy for the field's relative advancement. To avoid potential sample selection bias, we exclude the years immediately prior to the reform when calculating the percentages. Specifically, the proportion of Chinese patents in a technical field that have been cited by international patents between 2000 and 2006 is calculated to measure the proximity between Chinese technologies and the globally cutting-edge technologies in the field.⁸ The procedures are as follows:

- (1) For each technical field j among the 620 sub-classes (i.e., IPC4 categories), calculate the proportion of Chinese patents cited by international patents in year t (2000 $\leq t \leq$ 2006), R_{jt} , as follows:

$$R_{jt} = \frac{\text{Number of patents cited by international patents in year } t \text{ in technical field } j}{\text{Total number of approved patents in year } t \text{ in technical field } j}$$

- (2) Across all fields for each year, calculate the median of R_{jt} , $Med(R_t)$; and define field j as globally advanced (the control group) if $R_{jt} > Med(R_t)$ holds in at least 3 years between 2000 and 2006; otherwise, it is classified as relatively backward (the treatment group).

Based on the above identification criterion, 332 out of the 620 sub-classes of technical fields (i.e., IPC4 fields) are classified as relatively backward technical fields (i.e., the treatment group) and 288 as relatively advanced technical fields (i.e., the control group). Appendix A provides a list of sub-classes within different technical fields including agriculture and power generation to illustrate the validity of the classification method above in distinguishing between advanced and backward technologies in China.

⁷ The second amendment to the Patent Law of the People's Republic of China as well as the *Rules for the Implementation of the Patent Law* went into effect on July 1, 2001.

⁸ Although the frequency of Chinese patents being cited by international patents may be influenced by language barriers, in our view this should not constitute a concern with the validity of technical field division strategy in this paper for two reasons: (1) Multiple online patent databases and analytical tools exist that provide commercial patent citation services to assist information professionals in performing citation analysis on patents throughout the world in different languages, including PatSnap, Derwent, Aureka, Delphion, East Linden Doors, Patent Guider, and others ([Li & Meng, 2009](#)); and, (2) Patent applications analyzed in the current paper are all in Chinese, thus the comparison in their citations by international patents among different technical fields is still meaningful despite potential language barriers.

4.3. Model specification

We use the Difference-in-Differences (DID) estimation to empirically test the theoretical predictions outlined in Section 2.3, treating the Third Amendment to the Patent Law as a quasi-natural experiment. While many factors other than the patent law reform may also impact the probability of international citations and how it changes over time, these other factors would exert similar influence over all patents filed in China, without systematic differences across technological fields.⁹ By comparing the changes over time experienced by the treatment group with those by the control group, the DID methods thus can help distinguish the effects of the policy treatment from those of other factors. Specifically, the following specification is used to estimate the effects of approval standard change on patent quality:

$$Y_{ijpt} = \alpha + \beta \cdot Treatment_j \times Post_t + Z_{ijpt} \gamma + \eta_j + \eta_p + \eta_t + \varepsilon_{ijpt}, \quad (1)$$

where Y_{icf} is a patent quality measure for invention application i filing in technical field j in region p , year t , which is the indicator variable for patent grant applications (i.e., taking the value of 1 for an invention patent application eventually approved and 0 otherwise) when the sample includes all invention patents; while for the sample of invention grants, the quality measure is an indicator variable for being cited by international patents within 2 or 3 years of applications date (i.e., taking the value of 1 if cited within the time-frame and 0 otherwise).

The main variable of interest is the interaction term $Treatment_j \times Post_t$, where $Treatment_j$ takes the value of 1 if the technical field j is relatively backward and 0 otherwise, and $Post_t$ indicates whether the application date is after the newly amended *Patent Law* went into effect. Other determinants of patent quality are controlled for in the estimation, captured by Z_{icf} , a vector of patent characteristics (see the next section for details). To take into account of other unobservable factors that may influence patent quality, technical field fixed effects at the sub-classes level (i.e., IPC4) η_j and region fixed effects η_p are included to capture time-invariant technical characteristics and technique-invariant regional characteristics¹⁰, and year fixed effects η_t are used to capture factors that change over time and affect different technical fields and different regions in the same way. It is worth emphasizing that the stand-alone effects of $Treatment_j$ and $Post_t$ have been incorporated in η_j and η_t , respectively, thus no need to be included separately. Finally, ε_{ijpt} is the white-noise error term in the estimation model. To address potential issues of heteroscedasticity and serial correlation across both geographical and technological dimensions, we implement two-way clustering of standard errors at the city and IPC4 technical field levels, following [Cameron, Gelbach, and Miller \(2011\)](#). The results are robust to alternative clustering approaches, as discussed in the robustness section.

5. Main variables and summary statistics

The main variables used in the estimation include the following, and their summary statistics are given in [Table 1](#):

5.1. Dependent variable

We use several variables to measure the quality of patent applications or patent grants, including the following:

Probability of being cited. Patent quality can be measured as the probability of being cited by international patents, as forward citations have been found to reflect greater economic value and higher quality of technical innovation.¹¹ In our analysis, “foreign citations” refer to citations made by patents filed outside mainland China, as recorded in our citation dataset. A citation is defined as foreign if the citing patent is registered at a patent office other than the CNIPA. The citation data are sourced from the Patsnap (Zhihuiya) database, which integrates records from over 170 patent offices worldwide, including the USPTO, EPO, JPO, and WIPO, ensuring broad international coverage and minimizing jurisdictional bias. As the number of citations obtained by a patent depends on the length of time passed since its publication, we use a fixed window period of 2, 3 or 5 years after the application date when calculating how many citations a Chinese patent obtains from international patents to ensure comparability among patents. Given that the latest application year covered by our patent database is 2016, we are only able to derive citation information for patents applied by 2013 when the 3-year window period is used, and likewise, for patents applied by 2011 when using the 5-year window period.

Patent renewal. The decision to renew a patent can serve as a measure for patent quality, as patent owners need to pay maintenance fees to the relevant government agency to preserve the patent's validity and the annual maintenance fee rises substantially over time. In China, the cumulative maintenance fee for the first 3, 6, 10 and 20 years are RMB 2700, RMB 6300, RMB 16,300 and RMB 82,300, respectively. Obviously, it may not be worthwhile to pay the substantial maintenance fee for poor quality patents to be renewed ([Long & Wang, 2015](#)). Thus, we also use whether a patent is valid at a certain time (for example, 4 years, 5 years or 6 years after its application date) to measure its quality.

Patent invalidation. Once the patent is granted, other individuals and entities can request the Patent Reexamination Board of the State Council to declare the patent to be invalid. And when there is sufficient evidence to show that the patent granted no longer pos-

⁹ For example, greater accessibility of English-language equivalents will bring about more international citations for all Chinese patents over time, especially after the patent reform of 2009, but such an effect will happen not only for those fields that are technologically backward relative to international standards.

¹⁰ Regions in the current analysis refer to prefecture-level cities where the applicant is located; and for applicants filing from abroad, the region is assigned as ‘overseas’.

¹¹ [Kogan, Papanikolaou, and Seru \(2017\)](#) provide evidence that if the citation number increases by 1 for a patent, its economic value goes up by 0.1–3.2%, and [Hall & Jaffe \(2005\)](#) find similar results. And many studies have thus used the number of citations to proxy patent quality ([Akcigit & Kerr, 2018](#); [Moretti, 2021](#)).

Table 1
Descriptive statistics of main variables.

	Mean	Minimum	Maximum	Standard deviation	N
Dependent variables					
Prob. being cited within 2 year	0.0243	0	1	0.1541	1,951,013
Prob. being cited within 3 years	0.0615	0	1	0.2402	1,750,134
Prob. being cited within 5 years	0.1059	0	1	0.3077	1,235,959
Maintenance \geq 4 years	0.6736	0	1	0.4689	1,750,134
Maintenance \geq 5 years	0.6092	0	1	0.4879	1,487,847
Maintenance \geq 6 years	0.5580	0	1	0.4966	1,235,959
Complete invalidation within 5 years	0.0002	0	1	0.0153	1,487,847
Complete invalidation within 6 years	0.0003	0	1	0.0182	1,235,959
Independent variables					
Log(number of claims)	2.2020	0.6931	7.2004	0.6858	2,005,042
Log(number of pages)	2.6291	0.6931	7.9273	0.6143	2,005,042
Log(backward citations)	0.6558	0	3.8067	0.8354	2,005,042
Log(duration between application filing and substantive examination requesting)	2.5190	1.0986	4.9345	0.6800	2,005,042
Log(duration substantive examination)	3.1472	0.6931	4.9904	0.4161	2,005,042
Hired patent agency	0.9006	0	1	0.2992	2,005,042
Number of inventors:					
One	0.2621	0	1	0.4398	2,005,042
Two	0.1855	0	1	0.3887	2,005,042
Three-	0.1675	0	1	0.3734	2,005,042
Four and above	0.3849	0	1	0.4866	2,005,042
Type of applicants:					
company	0.6906	0	1	0.4622	2,005,042
higher education institution	0.1568	0	1	0.3636	2,005,042
individual	0.0894	0	1	0.2853	2,005,042
government agency	0.0089	0	1	0.0939	2,005,042
research institution	0.0532	0	1	0.2244	2,005,042
others	0.0011	0	1	0.0331	2,005,042

Notes: The sample size of invention patent applications is 2,005,042 after dropping observations with missing information. Noted that the observations for different dependent variables are different due to the truncation windows. For *prob.(being cited) within 2 years*, *prob.(being cited) within 3 years*, *prob.(being cited) within 5 years*, the sample sizes are 1,951,013, 1,750,134, 1,235,959, respectively. For *maintenance \geq 4 years* is 1,750,134, for *maintenance \geq 5 years* is 1,487,847, for *maintenance \geq 6 years* is 1,235,959. In all regression models, the independent variables are controlled for.

Data source: the CNIPA database.

sesses novelty, non-obviousness or usefulness after reexamination, the challenged patent will be invalidated. Thus, we use the complete invalidation outcome as an indicator for inferior patent quality and unstable patent right, since the patent right is still preserved for a patent ruled as partially invalid, albeit with a smaller number of claims.

5.2. Explanatory and control variables

In the DID estimations, the strategy is to compare how the approval standard change affects backward technical fields relative to advanced fields. Hence, the interaction term *Treatment* \times *Post* in regression model (1) is our main variable of interest. And we predict its estimated coefficient β to be significant and positive, indicating that the stricter patentability standards help to improve patent quality in China.

To take into account other determinants of patent citations, a set of patent characteristics are included as follows: (1) *the number of independent claims (in logarithm)*, which defines the scope of protection granted by the patent right and is thus positively correlated with patent quality; (2) *the number of pages (in logarithm)*, which indicates the complexity of the technology and the effort put into drafting the application, resulting in clear and well-defined claims and patent rights, thus an improvement in patent quality; (3) *the number of backward citations (in logarithm)*, which may impact patent quality for the same reasons as *the number of pages*; (4) *the time between application filing and substantive examination requesting (in logarithm)*, which is the time interval between the date of filing and that of initiating a request for substantive examination (in months) and could be positively or negatively correlated with patent quality either due to document preparation complexity, quality uncertainty¹²; (5) *duration of substantive examination (in logarithm)*, which is the time taken by the patent office to examine the substantive elements of an invention, including novelty, non-obviousness and usefulness, and thus could be positively or negatively correlated with patent quality either due to technological complexity or quality uncertainty; (6) *patent agency*, which is a dummy variable indicating whether the application is submitted via a patent agency, and thus could serve as a proxy for the size and resources of the inventors that may impact patent quality¹³; (7) *number of inventors*, which

¹² As the substantive examination process only begins after the applicants make a request and pay the related fees, the timing of the request may also reflect firm strategic behaviors, which may correlate with patent quality.

¹³ It is worth noting, however, that the absence of engagement with a patent agency does not necessarily imply lower patent quality, as larger companies often have their in-house intellectual property department, which takes charge of their own patent applications.

is a set of dummy variables corresponding to the number of inventors involved in inventing the innovative technology (1, 2, 3, or 4 and more). In the regression, we use the dummy variable corresponding to three inventors as the benchmark; and (8) *type of applicant*, which is another set of dummy variables indicating whether the patent's first applicant is of the following type, a company, a higher education institution, an individual, a firm, a government agency or others. For the below regression model, the dummy variable corresponding to a company as the benchmark. See Table 1 for summary statistics of the main variables used in the analysis.

6. Empirical analysis results

6.1. Baseline estimates

Table 2 reports the DID estimates for the effects of stricter patent approval standards on patents quality,¹⁴ with the sample here including only applications that are eventually granted patent rights.¹⁵ Our main variable of interest is $Treatment \times Post$, while the outcome variable is patent quality, measured by the probability of being cited within two years or three years of application, with results shown in columns (1)–(3) and (4)–(6), respectively. All regressions control for technical field, city and year fixed effects, with standard errors clustered at the sub-classes level of technical fields. In columns (1) and (4), no other control variables are included, whereas in columns (2) and (5), we introduce control variables comprising a vector of patent characteristics, as elaborated in Section 3.4.

Table 2 shows a statistically positive coefficient for the interaction term, $Treatment \times Post$, suggesting a quality improvement of granted patents in the backward fields relative to the advanced fields. Based on the findings in columns (2) and (5), the probability of being cited by international patents within two years or three years of the application date increases by 1.99 % and 3.11 %, respectively, after the implementation of the Third Amendment to the Chinese Patent Law in 2009. To gauge the magnitude of the effect, we compare our estimates with de Rassenfosse and Jaffe (2018), who document a 1.76–2.08 percentage-point rise in citation probability after the 1982 U.S. Patent Law Amendment Act, which raised patenting fees and filtered out low-quality applications. The comparable size of 2–3 percentage-point increase in our study suggests that China's 2009 reform generated an effect of similar scale compared to major institutional changes in other innovation-driven economies.

A potential concern with the estimations above is that the official 2009 implementation date may not capture the reform's true timing. The amendment's content was disclosed for public opinion in 2007 and 2008.¹⁶ Consequently, stakeholders (e.g., inventors and patent agencies) likely anticipated the stricter standards well before 2009, which could have biased our results. Applicants might have adjusted their behaviors *ex ante*. Specifically, inventors with low-quality innovations (i.e., those with insufficient novelty, especially in impacted fields) may have rushed to file before the stricter standards took effect. This would artificially lower the average quality of patents in 2007 and 2008, potentially over-estimating the post-reform (2009) treatment effect in our DID model.

To address this concern, we exclude patent applications in 2007 and 2008 to rerun the estimations with the results given in Columns (5) and (6) in Table 2. Reassuringly, the coefficient of the interaction term, $Treatment \times Post$, remains statistically positive for both citation probabilities, with the estimated magnitudes not statistically different from those estimated using the whole sample, thus alleviating the concern with earlier information disclosure. Therefore, we continue to use the sample for the whole period in the analysis that follows.

6.2. Parallel trend test

The key identifying assumption of our DID model is that, absent the reform, the treatment and control groups would have followed parallel trends in patent quality. To validate this assumption, we test for pre-existing differential trends by estimating the following dynamic model:

$$Y_{ijpt} = \alpha + \sum_{k=2002}^{k=2013} \beta_k Treatment_j \times Year_k + Z_{ijpt} \gamma + \eta_j + \eta_p + \eta_t + \varepsilon_{ijpt} \quad (2)$$

where Y_{ijpt} corresponds to the citation probability within two years of the patent application, $Year_k$ is a dummy variable that equals 1 for year k , with the other variables being the same as in eq. (1). The year 2008, which is one year prior to the amendment, is used as the reference period and is therefore excluded from the estimation. The parallel trend assumption implies no differential trends be-

¹⁴ The preliminary patterns depicted in Appendix B demonstrate the positive effects of the 2009 patent law amendment on the citation rate of international patents, offering initial insights into the favorable outcomes stemming from enhanced patent approval criteria.

¹⁵ For applications from abroad, the application located is decoded as 'overseas', which is treated as a separate city in estimations that include city fixed effects, as these applications can only be filed with the National Patent Office of China located in Beijing.

¹⁶ A *Draft of Amendments to the Patent Law of the People's Republic of China (an exposure draft)* (referred to as 'Exposure Draft' below) was drawn up together with relevant explanations in China National Intellectual Property Administration on August 2006, including detailed description of adopting stricter patent approval standards for patents for inventions and utility models. On December 27, 2006, the Exposure Draft was submitted to the State Council for examination and approval. Subsequently, the Legislative Affairs Office of the State Council sought advice, and discussed about and probed the revisions extensively. In March 2007, China National Intellectual Property Administration began to revise the Implementation Rules of the Patent Law, and also published research subject guidelines for revising the Implementation Rules, in which case, key problems that may be involved were listed and proposals requested. On March 2008, the first draft of the implementation rules of the Patent Law was formed. On December 27, 2008, the third amendment to the Patent Law was approved by the Standing Committee of the National People's Congress through deliberations.

Table 2
Patent approval standards and patent quality

Variables	(1)	(2)	(3)	(4)	(5)	(6)
	Prob(being cited) within 2 years			Prob(being cited) within 3 years		
Mean	0.0242	0.0242	0.0261	0.0614	0.0614	0.0617
Standard deviation	0.1538	0.1538	0.1595	0.2401	0.2401	0.2405
Treatment \times Post	0.0206** (0.0052)	0.0199** (0.0050)	0.0181*** (0.0062)	0.0326*** (0.0077)	0.0311*** (0.0071)	0.0261*** (0.0083)
Control variables	NO	YES	YES	NO	YES	YES
IPC4 FE	YES	YES	YES	YES	YES	YES
Region FE	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES
Excluding 2007 and 2008	NO	NO	YES	NO	NO	YES
N	1,951,013	1,951,013	1,637,237	1,750,134	1,750,134	1,436,358
R ²	0.0009	0.0068	0.0063	0.0010	0.0126	0.0120

Notes: In columns (1)–(3), the dependent variable is the dummy variable of Chinese patents being cited by international patents within 2 years of their application date; In columns (4)–(6), the dependent variable is the dummy variable of Chinese patents being cited by international patents within 3 years of their application date. In columns (1) and (4), no control variables are included. However, in columns (2)–(3) and (5)–(6), we introduce control variables comprising a vector of patent characteristics, as elaborated in Section 3.4. In columns (3) and (6), we exclude patent applications in 2007 and 2008. ***, ** and * denote statistical significance at the 10 %, 5 %, and 1 % levels, respectively.

Data source: the CNIPA database.

tween the treatment group and the control group prior to the 2008 amendment, i.e., the parameter β_k should not be significantly different from zero if $k < 2009$.

Fig. 2 plots the estimated coefficient and 95 % confidence interval of β_k for the years 2002–2013, with detailed estimates reported in Table 3. Clearly, the estimated coefficients for the probability of being cited within two years are not significantly different from zero (corresponding to that of patents applied in the baseline year of 2008) in the pre-2009 period but become significantly positive after 2008, highlighting a substantial improvement in patent quality for the treatment group relative to the control group. Recognizing that single-year significance tests may be sensitive to the choice of the base period, we further implement a joint significance test of pre-treatment coefficients (Roth, 2022). The joint F-test for the pre-reform period yields a p -value of 0.3480, indicating no systematic pre-trend differences, whereas the post-reform joint test yields a p -value of 0.0000, confirming a sharp and statistically significant rise in citation probability following the amendment. The consistency of both individual and joint estimates reinforces the credibility of the identification strategy and the robustness of the baseline findings.

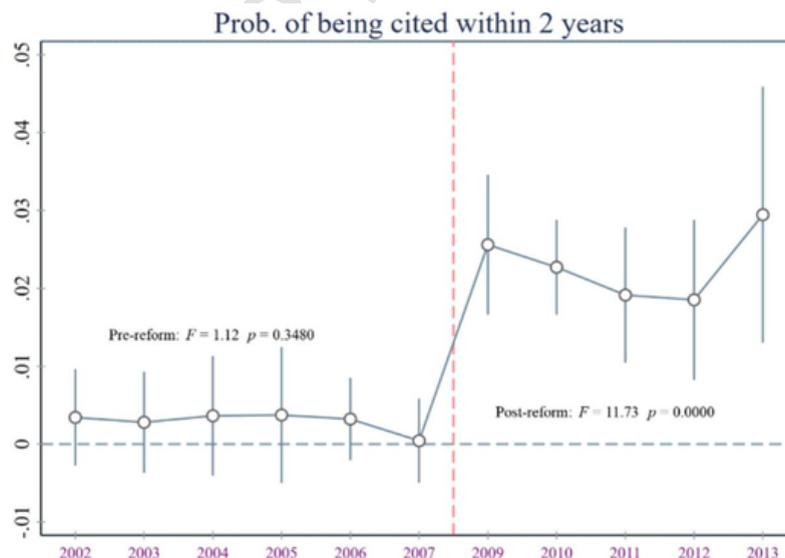


Fig. 2. Parallel trend test for citation probability within 2 years of the patent application.

Notes: This figure plots the dynamic treatment effects on the probability of being cited within two years, with 2008 as the reference year. The vertical bands represent the 95 % confidence intervals of each point estimate. Pre-2009 coefficients are statistically indistinguishable from zero, supporting the parallel trend assumption. The post-2009 estimates show a sharp and persistent increase, consistent with a policy-induced improvement in patent quality. Data source: the CNIPA database.

Table 3
Estimation results for parallel trend test.

Variable	(1)
	Prob(being cited) within 2 years
$Treatment \times Year_{2003}$	0.0050 (0.0032)
$Treatment \times Year_{2004}$	0.0051 (0.0038)
$Treatment \times Year_{2005}$	0.0048 (0.0038)
$Treatment \times Year_{2006}$	0.0050 (0.0046)
$Treatment \times Year_{2007}$	0.0043 (0.0029)
$Treatment \times Year_{2009}$	0.0016 (0.0026)
$Treatment \times Year_{2010}$	0.0256*** (0.0045)
$Treatment \times Year_{2011}$	0.0223*** (0.0031)
$Treatment \times Year_{2012}$	0.0191*** (0.0043)
$Treatment \times Year_{2013}$	0.0193*** (0.0048)
Control variable	YES
IPC4 FE	YES
Regional FE	YES
Year FE	YES
N	1,951,072
R ²	0.007

Notes: Table presents regression results implementing model (2), using the citation indicator for the 2-year windows as the outcome variable. Control variables represent a vector of patent characteristics introduced in Section 3.4. ***, ** and * denote significance at the 10 %, 5 %, and 1 % levels, respectively.

Data source: the CNIPA database.

6.3. Placebo test

To address the concern that the positive estimated effects might be driven by omitted variables rather than the amendment to the Patent Law, we conduct a placebo test by randomly assigning treatment status to IPC4-level technical sub-classes. Specifically, we randomly designate each IPC4 group as either treated or control, construct the corresponding placebo treatment variable, and re-estimate Eq. (1) using this falsified treatment assignment. We repeat this procedure 1000 times to generate a distribution of placebo estimates, with the outcome variable defined as the probability of a patent being cited within two years of application. If the true estimated treatment effect lies far in the tails of the placebo distribution, it suggests that our baseline results are unlikely to be driven by unobserved confounders. Fig. 3 plots the distribution of the placebo estimates, with the baseline coefficient marked by a red vertical line.

As shown in Fig. 3, the placebo estimates are symmetrically distributed around zero and closely resemble a normal distribution, while the actual estimate lies far in the tail. This sharp divergence supports the validity of the identification strategy and reinforces that the observed positive effect of stricter patentability standards on patent quality is not likely attributable to unobserved confounding factors.

6.4. Instrumental variable (IV) estimation

To further address the potential issue of endogeneity, we conduct the instrumental variable (IV) estimation in this section, and the average size of patent families in a technological field is chosen as the instrument for how advanced the field is relative to international standards. While the approval outcome of a patent is not directly impacted by how large a typical patent family is in the corresponding technological field, the size of the patent family correlates with the incidence of patent applications in foreign countries, with a larger family size indicating a higher likelihood of applying for patent protection in other jurisdictions and thus a relatively more advanced field. Given that both the exogeneity condition and the correlation criterion are satisfied, the average number of patent family members in the field qualifies as an appropriate instrument. Specifically, the IV is constructed following the steps below:

- (1) For each technical field j among the 620 sub-classes (i.e., IPC4 categories), calculate the average size of simple patent family in each technology field in year t ($2000 \leq t \leq 2006$), R_{jt} , as follows:
$$R_{jt} = \frac{\sum_{i=1, \dots, N} Num_fam_pat_{jt}}{N}$$

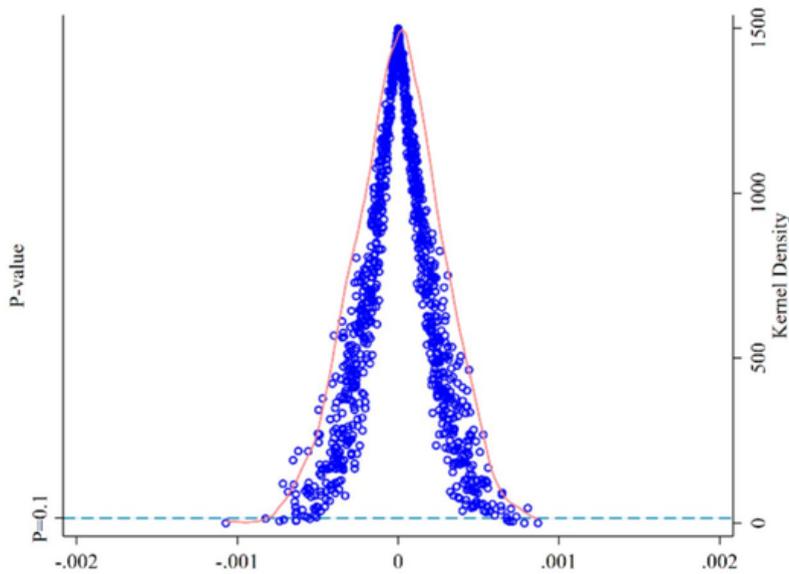


Fig. 3. Placebo test.

Notes: This figure presents the distribution of placebo estimates generated by randomly assigning treatment status to IPC4 technical sub-classes over 1000 iterations. The outcome variable is the probability that a patent is cited within two years of application. The placebo estimates are symmetrically distributed around zero and closely approximate a normal distribution, while the actual treatment effect is approximately 0.02. This stark deviation suggests that the probability of observing such an effect by chance is exceedingly low, thereby reinforcing the credibility of our identification strategy and indicating that the estimated effect is unlikely to be driven by unobserved confounding factors. Data source: the CNIPA database.

- (2) Determine the relative level of technical advancement of field j in year t using the following rule: If $R_{jt} \geq 3$ holds in at least 3 years between 2000 and 2006, then field j is defined to be globally advanced and classified into the control group ($Small_family = 0$); otherwise, the technical field j is deemed as relatively backward by world standard and thus classified into the treatment group ($Small_family = 1$).

We utilize *Small family* as the instrumental variable for the original policy variable and re-evaluate the effect of patent law amendments on patent quality, with the regression outcomes reported in Table 4. Column (1) and (3) of Panel B report strong first-stage relationships, with significantly positive coefficient and F-statistic exceeding conventional thresholds, confirming the strength of the instrument. The second-stage regression results in column (1) and (3) of Panel A show that more stringent patent granting standards result in an improvement in patent quality. While the IV estimate of patentability change's effect on patent quality is slightly larger than

Table 4
IV estimation.

	(1)	(2)	(3)	(4)
<i>Panel A: Second-stage</i>	<i>Prob(being cited) within 2 years</i>		<i>Prob(being cited) within 3 years</i>	
<i>Treatment × Post</i>	0.0295*** (0.0122)	0.0271*** (0.0078)	0.0367** (0.0163)	0.0606*** (0.0135)
<i>Panel B: First-stage</i>	<i>Treatment × Post</i>			
<i>Small_family × Post</i>	0.5975*** (0.0625)	0.6108*** (0.0616)	0.6044*** (0.0633)	0.6138*** (0.0628)
Control variable	YES	YES	YES	YES
IPC4 FE	YES	YES	YES	YES
Region FE	YES	YES	YES	YES
Year FE	YES	YES	YES	YES
IPC4 × Year trends	NO	YES	NO	YES
N	1,951,013	1,951,013	1,750,134	1,750,134
F stat	91.46	98.43	91.20	95.53
R ²	0.007	0.011	0.013	0.017

Notes: *Small family* is used as IV to re-estimate the impact of the Third Amendment on patent quality. Panel A reports the second-stage estimates, and Panel B reports the first-stage results. Columns (2) and (4) include IPC4-specific linear time trends. The instrument remains strong, with F-statistics exceeding 90 across specifications, and stricter patent granting standards are found to significantly improve patent quality. Control variables represent a vector of patent characteristics introduced in Section 3.4. ***, ** and * denote significance at the 10 %, 5 %, and 1 % levels, respectively.

Data source: the CNIPA database.

the baseline result, the standard error in the IV estimation is also larger, implying no significant difference between the IV estimate and the OLS estimate.

To further address potential correlations between the instrument and unobserved field-specific trends, we add technology field-specific linear time trends (at the IPC4 level) in the estimations. As shown in Columns (2) and (4) of both panels, the estimates remain highly consistent with the baseline, and the F-statistics continue to exceed 90, confirming the strength of our instrument. The robustness of our IV estimates after controlling for field-specific time trends thus provides further support for our identification strategy.

6.5. Robustness checks

To further bolster the validity of the findings, we perform a battery of robustness checks, including using alternative measures of citations and alternative measure of patent quality, using alternative estimation methods, as well as controlling for Strategic Emerging Industries and strategic adaptations possibilities.¹⁷ Overall, a consistent pattern emerges across the series of robustness checks, underscoring a significant improvement in patent quality after the Third Amendment to the Chinese Patent Law.

6.6. Alternative measures of citation

The various choices made when using patent citation to measure patent quality may impact its accuracy, such as citation window, inclusion of self-citations, and the choice of application date as the beginning of the citation period. We adopt alternative choices to construct the citation measure and conduct estimations in this section. Column (1) of Table 5 presents results using 5 years of the application date as the citation window, while Columns (2)–(3) of Table 5 show results with the citation measured constructed excluding self-citations. As shown in the table, the interaction term $Treatment \times Post$ is estimated to have a significantly positive coefficient throughout these specifications, providing support for the robustness of our main finding of a positive impact of the patentability change on patent quality.

And as patent citations can begin as soon as the patent's publication date, Columns (4)–(5) give results when the citation period is counted from the date of patent publication instead of the patent application date, again with similar estimation results. Finally, applicants may strategically choose the publication date of their patents during the application process, thus introducing self-selection bias into the citation measure. To avoid this potential influence of firm's publication date strategy, Columns (6)–(7) limit the citation counts to those occurring more than 18 months from the application date, with the coefficients revealing a slightly more pronounced effect in comparison to the baseline regression results.

6.7. Alternative measures of patent quality

Another concern with the preceding analysis is whether patent citation is an accurate measure for patent quality. We address this concern by adopting alternative measures for patent quality in this section. Another commonly used alternative measure for patent quality is whether a patent is renewed, or equivalently, whether the patent right is maintained, after a certain period. Consistent with international practices, Chinese patentees must pay annual fees to renew their granted invention patents, or to maintain their patent rights, and such fees increase as time goes by, implying higher renewal fees or maintenance costs for patents with longer lifespans. Therefore, patentees are willing to pay renewal fees only for higher quality patents as they have higher market values (Long & Wang, 2015), implying that patents still valid after 4 years, say, are of higher quality than those becoming invalid within the same time period. Thus, patent quality is measured by whether a patent is valid in 4, 5 or 6 years after the application date in this section, with the results shown in columns (1)–(3) of Table 6, estimating the same regression model as specified in Eq. (1). The coefficients of $Treatment \times Post$ are all positive and significant, suggesting that patent quality has been improved since the Third Amendment went into effect. Furthermore, the positive effect on patent quality is also quite large, with the renewal probability increased by 0.75 %, 3.17 %, and 4.96 %, respectively.

The probability of invalidation can also be used to measure patent quality, as higher-quality patents tend to have more stable patents rights, corresponding to a lower probability of invalidation (Long & Wang, 2015). To address potential issues stemming from truncation in our estimation results—specifically, the potential bias arising from the reduced time available for later patents to face challenges—we have maintained a fixed observation window of 5 to 6 years after the application date. The regression results using the complete invalidation indicator as the dependent variable are reported in columns (4) and (5) of Table 6. Despite the relatively small fraction of patents subject to invalidation litigation, it is noteworthy that the interaction term has a significant and negative coefficient in both estimations, which is also economically important. The Third Amendment to the Patent Law is again found to have statistically increased patent quality and stability.

6.8. Alternative estimation methods

Another concern relates to the empirical specification, as some of the dependent variables in our analysis are binary. In such cases, a nonlinear probability model (e.g., logit) may provide a more appropriate estimation framework than a linear probability model. We

¹⁷ We also conduct the following robustness checks, including using alternative model specifications incorporating interactive fixed effects or different clustering choices, and adopting alternative samples and alternative levels of aggregation. Due to space limit, results from these additional robustness tests are presented in Appendix C, with all the original main results preserved.

Table 5
Robustness test (alternative measures of citation)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Variables	<i>Prob</i> (being cited) within 5 years	<i>Prob</i> (being cited) within 3 years (non-self-citation)	<i>Prob</i> (being cited) Within 5 years (non-self-citation)	<i>Prob</i> (being cited) within 3 years (publication date)	<i>Prob</i> (being cited) Within 5 years (publication date)	<i>Prob</i> (being cited) within 3 years (excluding 18 months)	<i>Prob</i> (being cited) Within 5 years (excluding 18 months)
Mean	0.1059	0.0548	0.0993	0.0966	0.1424	0.0470	0.0954
Standard deviation	0.3077	0.2276	0.2990	0.2955	0.3495	0.2117	0.2938
<i>Treatment</i> × <i>Post</i>	0.0366*** (0.0065)	0.0257*** (0.0061)	0.0287*** (0.0063)	0.0125*** (0.0046)	0.0233*** (0.0032)	0.0392*** (0.0056)	0.0409*** (0.0060)
Control variables	YES	YES	YES	YES	YES	YES	YES
IPC4 FE	YES	YES	YES	YES	YES	YES	YES
Region FE	YES	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES	YES
<i>N</i>	1,235,959	1,750,134	1,235,959	1,750,134	1,235,959	1,750,134	1,235,959
<i>R</i> ²	0.0122	0.0111	0.0117	0.0116	0.0137	0.0073	0.0089

Notes: In column (1), the dependent variable is the dummy variable of Chinese patents being cited by international patents within 5 years of their application date; In columns (2)–(3), we exclude self-citations in order to construct the citation measures. In columns (4)–(5), we construct the citation period from the date of patent publication instead of the patent application date. In columns (6)–(7), we exclude citations within the first 18 months from the application date. Control variables include a vector of patent characteristics discussed in Section 3.4. ***, ** and * denote statistical significance at the 10 %, 5 %, and 1 % levels, respectively.

Data source: the CNIPA database.

Table 6
Robustness test (alternative measures of patent quality).

	(1)	(2)	(3)	(4)	(5)
Variable	Maintenance ≥4 years	Maintenance ≥5 years	Maintenance ≥6 years	Complete Invalidation Within 5 years	Complete Invalidation Within 6 years
Mean	0.7012	0.6424	0.5586	0.0002	0.0003
Standard deviation	0.4578	0.4793	0.4921	0.0153	0.0182
<i>Treatment</i> × <i>Post</i>	0.0075* (0.0045)	0.0317*** (0.0086)	0.0496*** (0.0139)	−0.0004*** (0.0001)	−0.0004*** (0.0001)
Control variables	YES	YES	YES	YES	YES
IPC4 FE	YES	YES	YES	YES	YES
Region FE	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES
<i>N</i>	1,750,134	1,487,847	1,235,959	1,487,847	1,235,959
<i>R</i> ²	0.0373	0.0511	0.1037	0.0002	0.0003

Notes: In columns (1)–(3), the dependent variable is dummy variables denoting whether the patent maintenance period exceeds 4, 5 or 6 years, respectively; and the dependent variable in columns (4)–(5) is a dummy variable indicating patent rights to be completely invalidated within 5 years or 6 years, respectively. Control variables include the same vector of patent characteristics as discussed in Section 3.4. ***, ** and * denote statistical significance at the 10 %, 5 %, and 1 % levels, respectively.

Data source: the CNIPA database.

re-estimate the baseline difference-in-differences specification using a logistic regression model, and the results are presented in Table 7. To facilitate direct comparison, we report the average marginal effects of the treatment variable rather than the raw log-odds coefficients. The estimated marginal effects from the logit model are highly consistent in both magnitude and significance with those obtained from the linear probability model. This consistency confirms that our main findings are not sensitive to the functional form of the probability model and further strengthens the robustness of our empirical conclusions.

It is also worth noting that nonlinear estimation procedures such as the logit model require iterative maximum-likelihood estimation, which becomes computationally intensive when handling large-scale datasets and multiple layers of fixed effects. In contrast, the linear probability model can efficiently accommodate high-dimensional fixed effects (IPC4, regional, and year) and produce coefficients directly interpretable as marginal effects.¹⁸ For these reasons, the linear probability model remains our preferred specification, consistent with prior empirical studies such as Heath and Mobarak (2015) and Bai and Jia (2016).

¹⁸ In our study that involves estimating the citation probability for over 1,700,000 patents, switching from the logistic model to the linear probability model reduces the estimation time from several hours to less than ten minutes.

Table 7
Robustness test (alternative estimation method).

Variables	Logit Model	
	Prob (being cited) within 2 years	Prob (being cited) within 3 years
	(1)	(2)
<i>Treatment</i> × <i>Post</i>	0.0187*** (0.0043)	0.0295*** (0.0051)
Control variables	YES	YES
IPC4 fixed effect	YES	YES
Regional fixed effect	YES	YES
Year fixed effect	YES	YES
<i>N</i>	1,949,713	1,749,005
Log-pseudolikelihood	-42,434.5	-364,086.7

Notes: Reported coefficients are average marginal effects, computed for each observation and then averaged using arithmetic means. The dependent variable for all columns is the dummy variable of a Chinese patent being cited by international patents within 3 years of its application date. Control variables include a vector of patent characteristics, as discussed in Section 3.4. ***, ** and * denote statistical significance at the 10 %, 5 %, and 1 % levels, respectively.

Data source: the CNIPA database.

6.9. Controlling for Strategic Emerging Industries (SEIs)

Another potential concern is that the observed improvement in patent quality following the 2009 Patent Law amendment might be partly driven by concurrent industrial policies—specifically, the promotion of China's Strategic Emerging Industries (SEIs). To address this concern, we first review the policy background. The SEIs initiative was formally introduced by the State Council in 2010 as a forward-looking strategy to guide China's future economic transformation. Importantly, the designation of SEIs was not based solely on pre-existing technological sophistication but rather on their anticipated strategic importance for long-term development. Consequently, both technologically advanced and relatively lagging fields could be identified as SEIs.

To empirically assess whether the SEIs policy confounds our identification, we match our dataset with the Classification of Strategic Emerging Industries and Corresponding IPC Codes released by Chinese authorities. Among the 630 IPC4 fields in our sample, 306 are categorized as SEIs, with 120 in the treatment group and 186 in the control group. We augment our baseline specification by including an interaction term between SEI classification and the post-2010 period to explicitly control for potential SEI-related policy effects:

$$Y_{ijpt} = \alpha + \beta (Treatment_j \times Post_t) + \delta (SEI_j \times Post_{2010,t}) + Z_{ijpt}\gamma + \eta_j + \eta_p + \eta_t + \varepsilon_{ijpt}$$

where SEI_j is a dummy variable equal to 1 if the IPC4 field j belongs to the strategic emerging industries, and $Post_{2010,t}$ indicates the period after the introduction of the SEIs policy. All other variables are defined as in the baseline specification. This interaction term allows us to control directly for potential policy effects associated with SEIs.

The results, reported in column (2) and (4) of Table 8, show that once the $SEI_j \times Post_{2010,t}$ interaction is included, the coefficient on $Treatment \times Post$ remains highly consistent in both magnitude and statistical significance. This indicates that our estimated effects are not driven by SEIs-related industrial policy support but by the patent law reform itself.

Table 8
Robustness test (controlling for strategic emerging industries)

Variables	(1)	(2)	(3)	(4)
	Prob (being cited) within 2 years		Prob (being cited) within 3 years	
<i>Treatment</i> × <i>Post</i>	0.0199*** (0.0050)	0.0206*** (0.0050)	0.0311*** (0.0071)	0.0319*** (0.0070)
<i>SEIs</i> × <i>Post_{2010}</i>		0.0044 (0.0032)		0.0057 (0.0042)
Control variables	YES	YES	YES	YES
IPC4 FE	YES	YES	YES	YES
Region FE	YES	YES	YES	YES
Year FE	YES	YES	YES	YES
<i>N</i>	1,951,013	1,951,013	1,750,134	1,750,134
<i>R</i> ²	0.0068	0.0068	0.0126	0.0126

Notes: Columns (1) and (3) report the baseline specifications, while Columns (2) and (4) incorporate additional controlling for *Strategic Emerging Industries* policy. Control variables include a vector of patent characteristics discussed in Section 3.4. ***, ** and * denote statistical significance at the 10 %, 5 %, and 1 % levels, respectively.

Data source: the CNIPA database.

6.10. Strategic adaptations test

Yet another potential concern is that the assumption of constant post-policy effects may overlook firms' strategic adaptations—such as shifting from invention patents to utility models—in response to the 2009 Patent Law amendment. To address this issue, we conducted an additional analysis using utility model data to examine possible substitution effects along two dimensions: patent quantity and quality. If such adaptations existed, we would expect to observe an increase in the number of utility model applications in treated technological fields, coupled with a decline in their average quality relative to the control group.

Using a difference-in-differences framework consistent with Eq. (1), we find the opposite pattern. As shown in Table 9, the number of utility model patents decreased, while their average quality improved after the reform. These results mirror the findings for invention patents, suggesting that the amendment did not trigger strategic substitution. This analysis reinforces the robustness of our main findings and alleviates concerns about potential dynamic adaptations. We acknowledge, however, that firm-level data would allow for a more granular investigation of patenting strategies. Future research could extend this analysis to explore cross-type patent substitution and better capture firms' dynamic adjustments following major institutional reforms.

7. Mechanism discussions

We now turn to explore the mechanisms that produce the remarkable improvement of patent quality after the enforcement of the Third Amendment to the Patent Law. Three mechanisms have been outlined through which patentability standards can impact patent quality in the theoretical analysis section (see Section 2.3), including the *screening-out* effect, where granted patents' quality is improved by rejecting application requests for lower-quality technologies based on stricter patent approval standards; the *self-selection* effect, where the overall quality of patent applications improves with fewer applications submitted for innovations with inferior quality; and the *foreign-inflow* effect, where more effective protection for international applicants due to the adoption of *absolute novelty* standard in the Third Amendment will attract more higher quality inventions from overseas. These mechanisms are empirically investigated in the current section.

7.1. Screening-out effect

After the 2009 amendment to the Patent Law was implemented, patent applications failing the *absolute novelty* patentability requirement would be screened out and rejected during substantive examinations, implying higher quality of patents eventually granted, and we refer to this process as the *screening-out* effect, through which the patentability change results in improved patent quality. However, as noted by Hu et al. (2009), whether this screening-out mechanism truly materializes remains an empirical question. They argue that the stricter novelty requirement focuses narrowly on the newness of inventions, which may not directly translate into higher overall patent quality. Moreover, patent examiners seldom use information on inventions practiced abroad but not publicly disclosed, limiting the practical impact of the new novelty standard.

To rigorously test this mechanism, we focus on patent applications that completed the full process of substantive examination, resulting in either a grant or rejection. In other words, patent applications that failed to apply for the substantive examination, withdrew during the substantive examinations process, or are still going through the substantive examination are excluded from the sample. It is worth noting that the sample size here is larger than that in the previous sections, which only examine patent grants. To identify which entities drive this mechanism, we further disaggregate the analysis across different types of applicants and intermediaries. Specifically, we examine heterogeneity by patent agents and applicant types—firms, universities, and individuals—to understand how different types of actors respond to the tightened examination standards.

Table 9
Robustness test (strategic adaptations test).

Variable	(1)	(2)
	<i>Ln (Number of applications)</i>	<i>Ln (Citations + 1)</i>
<i>Treatment</i> × <i>Post</i>	−0.1452*** (0.0428)	0.0504*** (0.0119)
Control variables	YES	YES
IPC4 FE	YES	YES
Region FE	–	YES
Year FE	YES	YES
N	7648	3,635,425
R ²	0.0260	0.0376

Notes: This table presents the results of a difference-in-differences analysis using utility model data to test for potential substitution effects along two dimensions: patent quantity and quality. Column (1) reports estimates at the sub-class level of technological fields (i.e., IPC4), where both the number of applications and patent characteristics are averaged at the IPC4 level. Because utility models in China are exempt from substantive examination, we do not control for the time between application filing and substantive examination requesting examination, duration of substantive examination. Column (2) reports the regression results at the patent level, with control variables including the full set of patent characteristics described in Section 3.4. ***, ** and * denote statistical significance at the 10 %, 5 %, and 1 % levels, respectively.

Data source: the CNIPA database.

The DID estimation results using model (1) are reported in Table 10, where the dependent variable Y_{itcf} is the indicator taking the value of 1 if patent application i filing in technical field j in region c , year t is rejected, and 0 otherwise. Column (1) shows that the coefficient on $Treatment \times Post$ is positive and statistically significant, indicating that increased rejection probability for patent applications in relatively backward technical fields after the *absolute novelty* standard is adopted, which is consistent with the existence of the *screening-out* effect. In other words, patent quality is enhanced by screening out applications of inferior quality in the substantive examination process.¹⁹

Columns (2)–(5) of Table 10 explore heterogeneous effects across the use of agencies and applicant types. Applications handled by professional agencies exhibit significantly higher rejection rates post-reform, implying that patents involving intermediaries underwent stricter scrutiny. Similarly, university patents faced higher rejection rates, suggesting that the reform disproportionately screened out lower-quality invention from academic researcher. In contrast, patents filed by individuals were less likely to be rejected, while firm-level patents showed no significant change, reflecting relatively stable internal quality controls within corporate R&D systems. Taken together, these findings provide compelling evidence that the screening-out mechanism was primarily activated through applications filed by agencies and university inventors, both of which tend to produce more heterogeneous-quality inventions. By tightening the novelty criterion, the 2009 reform effectively improved the overall quality composition of granted patents, not by uniformly raising quality across all applicants, but by selectively filtering out lower-quality filings in segments with greater variance in inventive standards.

7.2. Self-selection effect

In addition to the relatively straightforward *screening-out* effect, the adoption of *absolute novelty* standard may also lead to general quality improvement in all patent applications through *self-selection* effect, a behavioral adjustment of innovators facing stricter approval criteria. Regardless of whether a patent application is approved thus patent rights granted or not, it requires substantial expenses to pay for document preparation as well as procedural and substantive examinations, and patent agencies if hired. Therefore, given the lower probability of patent approval after the 2009 amendment to the Patent Law, innovators will choose not to file patent applications for innovations of inferior quality. In other words, only inventions more likely to meet the new patent approval standards will be selected to file for patent applications, thus the average quality of technical innovations included in patent applications will see a corresponding improvement, and such improvement should be greater in technical fields more impacted by the amendment (i.e., relatively backward fields).

We test for the existence of this mechanism by estimating model (1), where Y_{ijt} represents the quality of innovation i filing in technical field j in year t , measured by the probability of being cited by international patents within 3 years of its application date. As shown in columns (1) of Table 11, the interaction term $Treatment \times Post$ has a significant and positive coefficient, implying improved quality overall after the Third Amendment to the Patent Law. Given that the sample here includes all patent applications, regardless of whether they are eventually granted, and that patent applications also generate citations, which allows their quality to be measured accordingly, these results suggest that the stricter patentability standard has motivated innovators to self-select their high-quality technologies for patent applications. We have thus found evidence for the existence of the *self-selection* effect of the stricter patent approval standards.

Importantly, the heterogeneity analysis reveals which entities drive this mechanism, as shown in Columns (2)–(5) of Table 11. Patents filed through professional agencies exhibit the most pronounced post-reform improvement in quality, suggesting that intermediaries played a key role in quality screening and strategic adjustment. Among applicant types, company patents display the strongest quality gains, consistent with firms' higher capacity to assess technological merit and strategic value. By contrast, patents filed by universities and individuals show relatively modest quality improvements, indicating limited responsiveness to the higher approval threshold. Taken together, these findings provide robust evidence that the Third Amendment not only filtered out low-quality applications ex post (through the screening-out effect) but also induced ex ante behavioral adaptation among innovators (through the self-selection effect), thereby contributing to an overall upgrading of China's patent quality distribution.

7.3. Foreign-inflow effect

Besides the *screening-out* effect and the *self-select* effect, another important mechanism for the patent quality enhancement effect of stricter patentability standards to work is through the *foreign-inflow* effect, where the Third Amendment achieves more effective protection for overseas innovators, leading foreign inventors to respond by submitting more patent applications with higher-quality inventions. Specifically, an innovation would remain novel by Chinese standards before 2009, if it has not been publicly disclosed anywhere in the world or publicly practiced in China, and products adopting the innovation have not been sold in China. Note that under these conditions, a Chinese entity could file a patent application based on such an innovation, before the foreign inventor found the opportunity to submit a patent application in China, even if the technology had already been publicly used abroad or products using the innovation have been sold abroad. Thus, a Chinese entity that has seen the innovation being used or the products being sold abroad could apply for patents based on the same innovation in China, thus depriving the original inventor from overseas of their patent protection in China.

¹⁹ Also see Tao et al. (2021) for an argument that the substantive examination system in China helps ensure patent quality.

Table 10
Mechanism analysis: *Screening-out*.

Variables	(1)	(2)	(3)	(4)	(5)
	Prob(being rejected)				
<i>Treatment</i> × <i>Post</i>	0.0100*	−0.0005	0.0085	0.0087*	0.0144***
	(0.0051)	(0.0076)	(0.0057)	(0.0053)	(0.0051)
<i>Treatment</i> × <i>Post</i> × <i>Agency</i>		0.0144*			
		(0.0078)			
<i>Treatment</i> × <i>Post</i> × <i>Company</i>			0.0025		
			(0.0056)		
<i>Treatment</i> × <i>Post</i> × <i>University</i>				0.0094**	
				(0.0040)	
<i>Treatment</i> × <i>Post</i> × <i>Individual</i>					−0.0183***
					(0.0070)
Control variables	YES	YES	YES	YES	YES
IPC4 FE	YES	YES	YES	YES	YES
Region FE	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES
N	3,398,101	3,398,101	3,398,101	3,398,101	3,398,101
R ²	0.012	0.012	0.012	0.012	0.012

Notes: In column (1), the dependent variable is the dummy variable of a patent being rejected. Please note that the data here have been subjected to the entire process of substantive examination and can be used to show examination results of being “Rejected” or “Granted”. Columns (2)–(5) further introduce interaction terms with patent agency and applicant types to examine the heterogeneity of the screening-out effect and identify its sources. Control variables represent a vector of patent characteristics introduced in Section 3.4. ***, ** and * denote significance at the 10 %, 5 %, and 1 % levels, respectively.

Data source: the CNIPA database.

Table 11
Mechanism analysis: *Self-selection*.

Variables	(1)	(2)	(3)	(4)	(5)
	Prob(being cited) within 3 years				
<i>Treatment</i> × <i>Post</i>	0.0728***	0.0382**	0.0746***	0.0779***	0.0467**
	(0.0223)	(0.0180)	(0.0228)	(0.0227)	(0.0217)
<i>Treatment</i> × <i>Post</i> × <i>Agency</i>		0.0444***			
		(0.0149)			
<i>Treatment</i> × <i>Post</i> × <i>Company</i>			0.0356*		
			(0.0195)		
<i>Treatment</i> × <i>Post</i> × <i>University</i>				−0.0401**	
				(0.0189)	
<i>Treatment</i> × <i>Post</i> × <i>Individual</i>					−0.0199*
					(0.0110)
Control variables	YES	YES	YES	YES	YES
IPC4 FE	YES	YES	YES	YES	YES
Region FE	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES
N	3,390,319	3,390,319	3,390,319	3,390,319	3,390,319
R ²	0.007	0.007	0.007	0.007	0.007

Notes: In column (1), we test whether the average quality of the patent applications pool is improved since the enforcement of the Third Amendment, where the sample includes all patent applications, which is in contrast with the baseline regression sample of all patent grants. Columns (2)–(5) further introduce interaction terms with patent agency and applicant types to examine the heterogeneity of the self-selection effect and identify its sources. Control variables represent a vector of patent characteristics introduced in Section 3.4. ***, ** and * denote significance at the 10 %, 5 %, and 1 % levels, respectively. Control variables represent a vector of patent characteristics introduced in Section 3.4. ***, ** and * denote significance at the 10 %, 5 %, and 1 % levels, respectively.

Data source: the CNIPA database.

The phenomenon of “patent hijacking” described above was not uncommon, given the technological gap between China and the international frontiers before 2008. A *t*-test using our pre-2009 sample shows that foreign patents were cited by international patents 4.54 % more frequently than domestic patents, with a *t*-value of 26.44, showing that foreign patents indeed exhibited higher average quality. The shift from *relative novelty* to *absolute novelty* in the Third Amendment, however, would help thwart the preemptive filing behaviors of Chinese applicants by equalizing status of applicants from abroad with that of domestic ones. The 2009 amendment can also introduce the following additional channel for more effective patent protection for foreign innovators: By raising the patentability standards, resources for legal protection can now focus on a smaller number of high-quality patents now, thus permitting more resources and better protection for the remaining patents with more innovation content.

To test for the *foreign-inflow* effect, we study the sample of all patent applications to see whether more applications have been submitted by overseas filers after the Third Amendment to Patent Law. In the DID estimation, the dependent variable Y_{ijt} is a dummy indi-

cating whether the first applicant of invention i filing in technical field j in year t is from abroad. All other control variables are the same as in the other estimations, with the only exception of city fixed effects, which are omitted as all overseas patent applications are filed with the National Patent Office in Beijing. The estimation results are shown in column (1) of Table 12, where the interaction term $Treatment \times Post$ has a significant and positive coefficient, implying that the probability of being filed from overseas has increased by 5.29%. In other words, relative to Chinese domestic applicants, more overseas innovators have submitted their patent applications in China due to the enforcement of the Third Amendment to the Patent Law, providing support for the existence of the *foreign-inflow* mechanism.

Except for a higher percentage of applications from abroad, how has the quality of these patent applications been affected by the legal change? To empirically study the issue, we focus on the sample of patent applications filed from overseas using the DID estimation based on model (1), where Y_{ijt} represents the quality of invention i filed in technical field j in year t , measured by probability of international citation and global citing. Columns (2) of Table 12 report the estimated results for probability of being cited by international patents within 3 years of the patent's application date, while Columns (3) and (4) further explore whether these patents are more globally embedded in innovation networks. Specifically, Column (3) examines the likelihood that overseas-filed patents cite global (non-Chinese) prior art, and Column (4) restricts this to citations excluding both Chinese and home-country patents, thereby capturing linkages to a truly global innovation frontier. The positive and significant coefficients across these columns indicate that post-reform foreign patents not only receive more international citations but also draw more heavily on global technological knowledge. While all innovators value protection for their innovations, those with higher-quality inventions most likely assign an even greater weight to more effective patent protection. This may explain the pattern observed above where the Third Amendment not only brings in more foreign patent applications but also foreign applications with higher quality. As a result, the *foreign-inflow* mechanism works through both the *quantity* channel and the *quality* channel, where the quality channel may also be due to the *self-selection* mechanism at work in the sample of overseas applications.

8. Conclusion

In this study, we employ the DID estimation to explore the impacts of stricter patent approval standards on patent quality based on a quasi-natural experiment—the Third Amendment to the Chinese Patent Law in 2009, which exerts different effects on patents in relatively backward technical fields (the treatment group) and those in more advanced fields (the control group). An array of estimations produce consistent results linking the tougher standard for patent approval with higher probability of being cited by foreign patents, higher patent renewal rate, and lower probability of patent invalidation, thus providing empirical evidence for the argument that stricter patentability standards lead to patent quality improvement. While tougher patent approval standards are generally deemed to be conducive to patent quality improvement, there exists little empirical evidence in the literature. The current paper thus complements the existing studies by filling in the gap.

More importantly, to help understand the underlying channels that produce the causal effects, we propose and empirically test the existence of three mechanisms: the *screening-out* effect, the *self-selection* effect, and the *foreign-inflow* effect. Our findings show that stricter patent approval standards not only screen out the low-quality patent applications during the substantive examination process, but also motivate applicants to select higher-quality inventions for patent application in response to the lower probability of patent approval, as well as create more effective patent protection that attracts more overseas applicants and higher-quality overseas technologies, thus confirming the existence of the three mechanisms. In particular, the *foreign-inflow* effect is crucial for a country such as China, a country still in transition toward a fully market-oriented economy and has long been relying on imports in both products and technologies to build up its innovation capacity. While this is the first paper to provide quantitative evidence linking the details of the

Table 12
Mechanism analysis: *Foreign-inflow* effects.

Variable	(1) <i>Prob(filed by overseas applicants)</i>	(2) <i>Prob(being cited) within 3 year (overseas)</i>	(3) <i>Prob(citing global excl.CN)</i>	(4) <i>Prob(citing global excl.CN & home)</i>
Mean	0.3423	0.0904	0.1205	0.0792
S.D.	0.4745	0.4886	0.3256	0.2701
$Treatment \times Post$	0.0529** (0.0268)	0.0838*** (0.0190)	0.0490** (0.0142)	0.0410*** (0.0113)
Control variables	YES	YES	YES	YES
IPC4 FE	YES	YES	YES	YES
Year FE	YES	YES	YES	YES
N	4,989,150	1,350,189	1,707,549	1,707,549
R ²	0.282	0.004	0.357	0.221

Notes: In column (1), the dependent variable is the dummy variable of being owned by overseas applicants; and it is aimed at testing whether probability for abroad technologies to apply for patent protection in China increased since enforcement of the Third Amendment to the Patent Law. In column (2), the dependent variable is the dummy variable of overseas patents applications being cited by international patents within 3 years of their application date. In column (3), the dependent variable is the probability that overseas patent applications cite global (non-Chinese) prior art, while column (4) further excludes citations to both Chinese and home-country prior art to examine citation patterns focused purely on global sources. Control variables represent a vector of patent characteristics introduced in Section 3.4. ***, ** and * denote significance at the 10 %, 5 %, and 1 % levels, respectively.

Data source: the CNIPA database.

patent system with patent quality in the context of China, the finding that conformity with international criteria helps improve patent quality is most likely applicable to other developing countries as well.

Admittedly, the three mechanisms explored in this paper only capture the short-term effects of patentability standard changes, assuming unchanged technological innovation processes. In the longer term, stricter patentability standards may enhance overall innovation quality by strengthening patent protection, encouraging domestic R&D investment, and promoting the diffusion of international technologies through increased foreign patent filings. Yet these potential benefits are accompanied by notable trade-offs. Tighter novelty and inventiveness criteria raise both administrative and compliance costs, particularly for small and medium-sized enterprises (SMEs) and individual inventors, potentially deterring their participation in patenting (Tagliatalata & Barontini, 2024). Moreover, by elevating the threshold for patentability, such reforms may inadvertently suppress incremental or adaptive innovation, an essential driver of diffusion-based technological progress in developing economies (Porter, 2001). These tradeoffs highlight a central tension in patent policy: while stricter standards may prevent the “enclosure of knowledge” by reducing low-quality patents, they may also reduce the motivation for cumulative, follow-on innovations. This concern is particularly relevant in the context of developing countries, where patent strengthening reforms may have heterogeneous and sometimes dampening effects on domestic innovative activity.

Overall, while stronger patent regimes can enhance innovation quality, complementary measures are essential to offset higher administrative and compliance costs and ensure broad technological participation, including but not limited to targeted SME support, streamlined procedures, and clear legal guidance. Future research will be needed extend this analysis to capture the long-term, general equilibrium effects of patent reforms by integrating firm-level innovation behaviors, cross-border knowledge flows, and institutional evolution within a unified analytical framework.

Uncited references

Declaration of competing interest

We do not have conflicts of interest to report.

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Data availability

Data will be made available on request.

Appendix A. Preliminary check of the validity of the classification method

As a preliminary check of the validity of the classification method for identifying the treatment and control groups, the sub-classes of technical fields (i.e., IPC4 fields) corresponding to the control and treatment groups are listed for classes A01 and H02 (i.e., IPC3 fields), respectively, in Table A1, together with the detailed descriptions of each technical field. As shown in the table, for class A01 (agriculture, forestry and animal husbandry), the classification standards described in Section 3.2 imply that sub-class A01J belongs to the control group of relatively advanced technologies, mainly including dairy product processing technologies. In reality, China's dairy product processing technologies have indeed reached relatively advanced level, with leading firms such as Bright Dairy, Mengniu Dairy (Monmilk), and Yili constantly improving their production technologies. In contrast, both sub-classes A01N and A01P fall into the treatment group of relatively backward technologies, which primarily include technologies in the bio-pesticide field.²⁰ Indeed, bio-pesticides in China are mostly generic products modeled after foreign products and only a small number are proprietary products, implying a giant gap in comparison with developed countries. The quality of bio-pesticides is poor as well (Qiu, 2007).²¹

Furthermore, we can compare the quantity and proportion of sub-classes (i.e., IPC4 fields) in the treatment and control groups for different classes (i.e., IPC3 fields) as a validity check. Out of the 12 sub-classes of technical fields (IPC4) in class A01 (agriculture, forestry, animal husbandry, hunting, trapping, and fishery), 11 belong to the relatively backward treatment group, accounting for

²⁰ Patents from the bio-pesticide field are identified based on IPC numbers of A01N and A01P (see Liu, Liu, & Liu, 2016).

²¹ Similarly, in class H02 (power generation, power transformation, power distribution, etc.), H02J and H02H are categorized into the relatively advanced control group using the proposed standards, while H02B and H02G belong to the relatively backward treatment group. Such classification is also consistent with the fact that China holds a leadership position in extra-high-voltage related technical fields. For example, China possesses cutting-edge technologies in AC/DC transmission and distribution equipment in the world, and boasts of an independent innovation system of extra-high voltage products. In contrast, class H02 also consists of sub-classes of technical fields where China is relatively backward, for instance, the sub-class of H02B (for technical inventions of switchboards for power supply and distribution, as well as transformer substations and switch gears). Although China holds apparent advantages in power generation, transmission and transformation fields, it still lags behind the internationally advanced levels in distribution automation (Chang, Xue, & Yang, 2009).

91.67 % of the total number of sub-classes in the class. This indicates that Chinese patents in the technical field of agriculture, forestry, fishery, and animal husbandry (A01) are rarely cited by international patents, accurately reflecting the reality of technological backwardness in the country's agriculture.²² As for the 8 IPC4 technical fields in H02 (power generation, transformation or distribution), 6 of them belong to the control group (i.e., relatively advanced fields by world standard), while those in the treatment group only account for 25 % of the sub-classes. This pattern indicates that patents from the corresponding technical fields are frequently cited in international patents, showing that China has taken a relatively advanced position in these technical fields. Apparently, the classification method used in the current paper has produced outcomes that are largely in line with reality.

Table A1

Example of control and treatment groups.

Class (IPC3)		A01 (Agriculture, forestry, animal husbandry, hunting, trapping and fishing)	H02 (Power generation, power transformation and power distribution, etc.)
Sub-class (IPC4)	Number of sub-classes in control groups	1	6
	Number of sub-classes in treatment groups	11	2
	Proportion of sub-classes in treatment group	91.67 %	25.00 %
	Control group	A01J: Dairy product processing (including storage, pasteurization and sterilization)	H02J: Circuit assembly or systems for power supply or distribution; and power storage systems H02H: Emergency protective circuit assembly H02M: AC/AC, AC/DC, and DC/DC conversion equipment, etc.
	Treatment group	A01G: Gardening; cultivation of vegetables, flowers, fruit trees, grapes and lupulus A01N: Biocides, for example, used as sanitizers, farm chemicals and herbicides; pest repellents or attractants; plant growth regulators A01P: Chemical compounds or preparations for killing livestock, fowls, etc., luring pests, or regulating plant growth activities	H02B: Switchboards, transformer substations or switching devices, and other devices for power supply or distribution H02G: Cable or wire installation; or installation of Photoelectric composite cables or wires

Notes: The control group refers to technical fields that are relatively advanced by international standards, which are not impacted by the revision in patent law; whereas the treatment group includes relatively backward technical fields, which are impacted by the patent law revision. The *proportion of sub-classes in treatment group* is calculated as the proportion of relatively backward technical fields by sub-classes (IPC4) in the corresponding technical class (IPC3). The greater the ratio is, the larger the gap between a class of technical fields and its international counterpart.

Data source: the CNIPA database.

Appendix B. Preliminary patterns of the 2009 Amendment's impact on patent quality

As the scope expansion of 'prior art' in the 2009 amendment raises the patent approval standards with different impacts on different technical fields, Fig. A1 plots how the ratio of patents cited by international patents changed before and after the 2009 amendment for the treatment and control groups, respectively. Specifically, the figure shows the ratio of patents cited by international patents within 2 years of application, with the dashed line showing the pattern for the relatively backward technical fields (i.e., the treatment group), whereas the solid line for the relatively advanced technical fields (i.e., the control group).

²² As pointed out by Hu, Zhu, Xin, Hou, and Wang (2018), the technological level of Chinese agriculture at present is comparable to that of the United States at the end of the 1960s, that of the United Kingdom in the early 1980s, or that of Japan in the early 1990s.

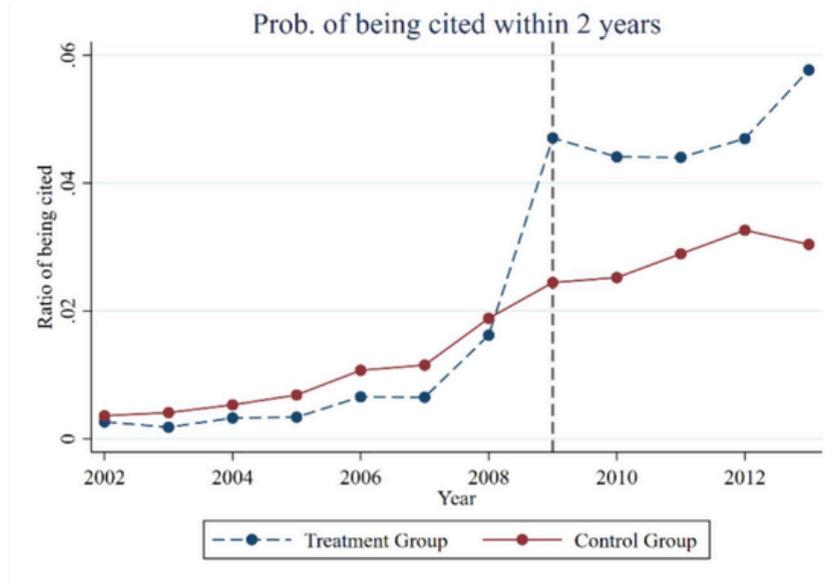


Fig. A1. Changes in International Citations of Treatment and Control Groups.

Notes: The graph in Fig. A1 gives the ratio of patents cited by international patents within 2 years of application, with the dashed lines showing the patterns for the relatively backward technical fields (i.e., the treatment group), whereas the solid lines for the relatively advanced technical fields (i.e., the control group). Data source: the CNIPA database.

As expected, the solid line does not exhibit abrupt fluctuations around 2008–2009, implying that the probability of being cited by international patents has not changed substantially for the control group during the period when the Third Amendment was passed and implemented. In contrast, there was a significant increase in the citation ratio by international patents for the treatment group in 2009, the first year of the new law's enforcement, as shown in the dashed line. Furthermore, Fig. A1 shows that the Chinese patents in the backward technical fields were slightly more likely to be cited than the patents in the advanced technical fields before 2009; yet the pattern has been reversed since, with patent citation ratio for the treatment group exceeding that for the control group. As the control group is less impacted by the Third Amendment, the above pattern gives preliminary evidence that the stricter patent approval standards had a positive effect on patent quality. To provide more rigorous evidence for the pattern exhibited in Fig. A1, we now turn to the DID estimation to identify the causal effects of the stricter patent approval standards on patent quality.

Appendix C. Robustness checks

To further bolster the validity of the findings, a battery of robustness checks are conducted, including alternative model specifications incorporating interactive fixed effects or different clustering methods, alternative measure of patent quality, as well as alternative samples and alternative levels of aggregation for sensitivity check.

C.1. Interactive fixed effects

To further address concerns that unobserved regional or industry-specific innovation dynamics may bias our estimates—despite controlling for an extensive set of patent-level covariates, IPC4 fixed effects, region fixed effects, and year fixed effects—we augment the baseline specification with interactive fixed effects. Specifically, we include region-year fixed effects to capture time-varying regional shocks and region-IPC4 fixed effects to account for persistent differences in innovation intensity across regional-technical domains. These controls strengthen identification by ruling out the potential influence of policy shocks after 2009 and by isolating the policy effect from localized innovation patterns and technic-specific trajectories.

Table C1 presents the results. Columns (1) and (2) sequentially introduce region-year and region-IPC4 fixed effects; column (3) includes both. Across all specifications, the estimated effect of stricter patent approval standards on the probability of being cited within two years remains positive and statistically significant, closely aligning with baseline estimates. Columns (4) to (6) replicate the analysis using the probability of being cited within three years as the outcome and yield similarly robust results. These findings reinforce the credibility of our identification strategy and suggest that the observed improvements in patent quality are attributable to the policy-induced tightening of patentability standards, rather than to unobserved heterogeneity in regional or industrial innovation trends.

Table C1
Robustness test (Interactive fixed effects).

Variables	(1)	(2)	(3)	(4)	(5)	(6)
	Prob(being cited) within 2 years			Prob(being cited) within 3 years		
Mean	0.0242	0.0242	0.0242	0.0614	0.0615	0.0615
Standard deviation	0.1538	0.1538	0.1538	0.2402	0.2402	0.2402
Treatment × Post	0.0212*** (0.0040)	0.0228*** (0.0041)	0.0232*** (0.0032)	0.0338*** (0.0060)	0.0320*** (0.0062)	0.0349*** (0.0053)
Control variables	YES	YES	YES	YES	YES	YES
Region-Year FE	YES	–	YES	YES	–	YES
Region-IPC4 FE	–	YES	YES	–	YES	YES
IPC4 FE	YES	–	–	YES	–	–
Year FE	–	YES	–	–	YES	–
N	1,950,880	1,943,696	1,943,543	1,750,002	1,742,690	1,742,536
R ²	0.006	0.007	0.006	0.012	0.013	0.012

Notes: Columns (1)–(3) sequentially add region-year fixed effects, region-IPC4 fixed effects, and both, to account for time-varying regional shocks and persistent regional-technical heterogeneity. Columns (4)–(6) replicate the analysis using citation within three years as the dependent variable. Control variables include a vector of patent characteristics discussed in Section 3.4. Standard errors are clustered at the IPC4 and city level. ***, ** and * denote statistical significance at the 10 %, 5 %, and 1 % levels, respectively.

Data source: the CNIPA database.

C.2. Alternative clustering choices

Table C2 presents robustness checks under alternative clustering assumptions. While our baseline results rely on two-way clustering at the IPC4 and city levels, we re-estimate the regressions using one-way clustering to assess the sensitivity of the standard errors. Columns (1) and (3) report results clustered at the IPC4 level, while Columns (2) and (4) cluster at the city level, allowing for intra-city correlation in the error terms. Across all specifications, the coefficients of interest remain statistically significant at the 1 % level, suggesting that our findings are not sensitive to the choice of clustering strategy and remain robust to alternative assumptions about the structure of the error term.

Table C2
Robustness test (Clustering choices)

Variables	(1)	(2)	(3)	(4)
	Prob(being cited) within 2 years		Prob(being cited) within 3 years	
Mean	0.0242	0.0242	0.0614	0.0614
Standard deviation	0.1538	0.1538	0.2401	0.2401
Treatment × Post	0.0199*** (0.0041)	0.0199*** (0.0035)	0.0311*** (0.0063)	0.0311*** (0.0044)
Cluster level	IPC4	City	IPC4	City
Control variables	YES	YES	YES	YES
IPC4 FE	YES	YES	YES	YES
Region FE	YES	YES	YES	YES
Year FE	YES	YES	YES	YES
N	1,951,013	1,951,013	1,750,134	1,750,134
R ²	0.007	0.007	0.013	0.013

Notes: Columns (1) and (3) cluster standard errors at the IPC4 level; Columns (2) and (4) at the city level. Control variables include a vector of patent characteristics discussed in Section 3.4. ***, ** and * denote statistical significance at the 10 %, 5 %, and 1 % levels, respectively.

Data source: the CNIPA database.

C.3. Alternative samples

Another concern is that the choice of the treatment and control groups in the data sample may not accurately reflect the influence experienced by patents in related group from the stricter patent approval standards, for instance, the inclusion of patent applications filed under the Patent Cooperation Treaty (PCT) in the treatment group. As an international patent treaty, the PCT already provides a set of unified procedures for filing patent applications and protecting patent rights in each of the contracting countries (Wen & Zhang, 2018). In particular, one key feature of the PCT application procedures is the international patent search report, which requires the claims in the current filing to be compared with prior art (including patents and publications) world-wide, to determine their novelty

and non-obviousness²³ Therefore, under normal circumstances PCT applications should be filed only for technical innovations whose quality meets international patentability standards, even for Chinese applicants in the relatively backward technical fields, thus these patents would not be affected by the patent approval standards changes of the Third Amendment in the same way as other patents.

To address the potential issue of PCT applications experiencing different effects from the Third Amendment, we exclude all PCT applications from the sample to conduct the DID estimation as a robustness test, with the results reported in columns (1) and (2) of [Table C3](#). The coefficient of the interaction term *Treatment* × *Post* remains positive and statistically significant. Furthermore, the magnitudes of the estimates are not significantly different from those for the whole sample (see columns (2) and (5) in [Table 2](#)).

Table C3
Robustness tests (alternative samples).

Variable	(1)	(2)	(3)	(4)
	No PCT		Technical level	
	Prob (being cited) within 2 years	Prob (being cited) within 3 years	Prob (being cited) within 2 years	Prob (being cited) within 3 years
Mean	0.0285	0.0725	0.0192	0.0424
S.D.	0.1664	0.2594	0.0413	0.0570
<i>Treatment</i> × <i>Post</i>	0.0188*** (0.0055)	0.0304*** (0.0076)	0.0265*** (0.0025)	0.0421*** (0.0039)
Control variables	YES	YES	YES	YES
IPC4 FE	YES	YES	YES	YES
Region FE	YES	YES	–	–
Year FE	YES	YES	YES	YES
<i>N</i>	1,573,662	1,375,094	7191	6593
<i>R</i> ²	0.0070	0.0121	0.0414	0.0589

Notes: In column (1) and (2), we exclude all PCT applications from the sample, and the dependent variables are the dummy variables of Chinese patents being cited by international patents within 2 or 3 years of their application date, respectively. In column (3) and (4), we report the estimates at the sub-classes level of technical fields (i.e., IPC4), and both dependent variables and control variables take their mean values at the IPC4 level. Control variables include a vector of patent characteristics discussed in Section 3.4. ***, ** and * denote statistical significance at the 10 %, 5 %, and 1 % levels, respectively.

Data source: the CNIPA database.

While the previous estimations are based on patent level data, we also report the estimates at the sub-classes level of technical fields (i.e., IPC4) to check the sensitivity of the analysis. All the regressions include year fixed effects, IPC4 fixed effects, and patent characteristics (including number of independent claims, number of pages, number of backward citations, the time between application filing and substantive examination requesting examination, duration of substantive examination, patent agency, number of inventors, type of applicant, and see Section 3.4 for more details), where both dependent variables and control variables take their mean values at the IPC4 level. The results are reported in column (3) and (4) in [Table C3](#), where the coefficient of the interaction term is consistently positive and statistically significant. The estimates imply increases in the probability of being cited by international patents within 2 years of 2.65 %, due to the Third Amendment, giving effects of similar magnitude as compared with the results from the patent level analysis. These results demonstrate the robustness of the significant and positive impact of stricter patent approval standards on patent quality.

C.4. Alternative definition of technological advancement

To address potential biases in classifying technological fields as “backward” or “advanced” based on pre-reform international citations—such as language or database coverage effects—we re-define technological advancement using patent family size as an alternative indicator. Patent family size captures the global scope of patent protection, with larger families reflecting broader international patenting and higher technological sophistication. For each technical field *j* (IPC4 level), we compute the average number of simple patent family members during 2000–2006:

$$R_{jt} = \frac{\sum_{i=1}^N \text{Num_fam_pat}_{jt}}{N}$$

If $R_{jt} \geq 3$ in at least three of the pre-reform years, field *j* is classified as “advanced” (*Treatment* = 0); otherwise, it is categorized as “backward” (*Treatment* = 1).

We then re-estimate the baseline DID model using this alternative treatment definition. As shown in [Table C4](#), the results remain robust: patents in relatively backward fields exhibit significantly greater improvements in international citation probability following the Third Amendment. This confirms the validity of our identification and treatment-group classification.

²³ Patent application procedures of PCT consists of providing international search reports and written opinions; and an important content in the international search report is to compare the technology applying for patent right with the prior art (i.e., patents and literature) in novelty and inventiveness.

Table C4
Robustness test (alternative definition of technological advancement)

Variables	(1)	(2)	(3)	(4)
	Prob(being cited) within 2 years		Prob(being cited) within 3 years	
Mean	0.0242	0.0242	0.0615	0.0615
Standard deviation	0.1538	0.1538	0.2402	0.2402
Treatment × Post	0.0187** (0.0078)	0.0177** (0.0078)	0.0252** (0.0103)	0.0223** (0.0103)
Control variables	NO	YES	NO	YES
IPC4 FE	YES	YES	YES	YES
Region FE	YES	YES	YES	YES
Year FE	YES	YES	YES	YES
N	1,951,072	1,951,072	1,750,187	1,750,187
R ²	0.0001	0.0060	0.0001	0.0118

Notes: We re-define technological advancement based on patent family size, which reflects the global scope of patent protection and technological sophistication. In columns (1)–(2), the dependent variable is the dummy variable of Chinese patents being cited by international patents within 2 years of their application date; in columns (3)–(4), the dependent variable is the dummy variable of Chinese patents being cited by international patents within 3 years of their application date. In columns (1) and (3), no control variables are included. However, in columns (2) and (4), we introduce control variables comprising a vector of patent characteristics, as elaborated in Section 3.4. ***, ** and * denote statistical significance at the 10 %, 5 %, and 1 % levels, respectively.

Data source: the CNIPA database.

References

- Akcigit, U., & Kerr, W.R. (2018). Growth through heterogeneous innovations. *Journal of Political Economy*, 126(4), 1374–1443.
- Bai, J. (2009). What does the third amendment to China's patent law mean to you. Jones Day.
- Bai, Y., & Jia, R. (2016). Elite recruitment and political stability: The impact of the abolition of China's civil service exam. *Econometrica*, 84(2), 677–733.
- Barton, J.H. (2000). Reforming the patent system. *Science*, 287(5460), 1933–1934.
- Basheer, S. (2005). India's tryst with TRIPS: The patents (amendment) act, 2005. *Indian Journal of Law and Technology*, 1, 15.
- Boldrin, M., & Levine, D.K. (2008). Perfectly competitive innovation. *Journal of Monetary Economics*, 55(3), 435–453.
- Cameron, A.C., Gelbach, J.B., & Miller, D.L. (2011). Robust inference with multiway clustering. *Journal of Business & Economic Statistics*, 29(2), 238–249.
- Chang, K., Xue, F., & Yang, W. (2009). Review on the basic characteristics and its technical progress of smart grid in China. *Automation of Electric Power Systems*, 33(17), 10–15. (in Chinese).
- Crespi, G., & Zuniga, P. (2012). Innovation and productivity: Evidence from six Latin American countries. *World Development*, 40(2), 273–290.
- Dreyfuss, R.C. (2008). Nonobviousness: A comment on three learned papers. *Lewis & Clark Law Review*, 12, 431.
- Eisenberg, R.S. (2004). Obvious to whom—evaluating inventions from the perspective of PHOSITA. *Berkeley Technology Law Journal*, 19, 885.
- Erstling, J.A., & Strom, R.E. (2009). Korea's patent policy and its impact on economic development: A model for emerging countries? *San Diego International Law Journal*, 11, 441.
- Farrell, J., & Shapiro, C. (2008). How strong are weak patents? *American Economic Review*, 98(4), 1347–1369.
- Feng, G., Zheng, M., Wen, J., & Zhang, C. (2020). What determines the Chinese firms' technological innovation: A re-empirical investigation based on the previous empirical literature of nine Chinese economics top journals and a-share listed company data. *China Industrial Economics*, 1, 17–35. (in Chinese).
- Heath, R., & Mobarak, A.M. (2015). Manufacturing growth and the lives of Bangladeshi women. *Journal of Development Economics*, 115, 1–15.
- Hu, A.G., & Jefferson, G.H. (2009). A great wall of patents: What is behind China's recent patent explosion? *Journal of Development Economics*, 90(1), 57–68.
- Hu, Z., Zhu, D., Xin, L., Hou, L., & Wang, D. (2018). Comparison study on the level of international agricultural modernization based on the method of generation gap of industry elements. *Scientia Agricultura Sinica*, 51(7), 1412–1420. (in Chinese).
- Hu, Z.C., Li, J., Zhang, X., Yu, P., Zhou, J., Fei, L., ... Wang, X. (2009). The life of law lies not in logic but in experience. *Electronics Intellectual Property*, 5, 20–23 + 27. (in Chinese).
- Kogan, L., Papanikolaou, D., & Seru, A. (2017). Technological innovation, resource allocation, and growth. *The Quarterly Journal of Economics*, 132(2), 665–712.
- Lamoreaux, N.R., & Sokoloff, K.L. (2001). Market trade in patents and the rise of a class of specialized inventors in the 19th-century United States. *American Economic Review*, 91(2), 39–44.
- Lemley, M.A., & Shapiro, C. (2005). Probabilistic patents. *Journal of Economic Perspectives*, 19(2), 75–98.
- Li, R., & Meng, L. (2009). On the problems in patent citation analysis. *Information Studies: Theory & Application*, 32(7), 39–43. (in Chinese).
- Lichtman, D., & Lemley, M.A. (2007). Rethinking patent law's presumption of validity. *Stanford Law Review*, 60, 45.
- Lin, B., Wood, J., & Jang, S. (2004). Overview of Chinese patent law. *35th international congress of the PIPA* (pp. 19–22).
- Liu, X., Liu, F., & Liu, C. (2016). Early warning report of biological pesticide industry based on patent information analysis. *Journal of Intelligence*, 35(11), 86–92. (in Chinese).
- Long, C.X., & Wang, J. (2019). China's patent promotion policies and its quality implications. *Science and Public Policy*, 46(1), 91–104.
- Long, X., & Wang, J. (2015). China's patent explosion and its quality implications. *The Journal of World Economy*, 38(6), 115–142. (in Chinese).
- Moretti, E. (2021). The effect of high-tech clusters on the productivity of top inventors. *American Economic Review*, 111(10), 3328–3375.
- Mueller, J.M. (2006). The tiger awakens: The tumultuous transformation of India's patent system and the rise of Indian pharmaceutical innovation. *University of Pittsburgh Law Review*, 68, 491.
- Noveck, B.S. (2006). Peer to patent: Collective intelligence, open review, and patent reform. *Harvard Journal of Law & Technology*, 20, 123.
- Porter, M.E. (2001). The competitive advantage of nations. *Harvard Business Review*, 68(2), 73–93.
- Qiu, D. (2007). Current situation and prospects of bio-pesticides in China. *Plant Protection*, 5, 27–32. (in Chinese).
- de Rassenfosse, G., Griffiths, W.E., Jaffe, A.B., & Webster, E. (2021). Low-quality patents in the eye of the beholder: Evidence from multiple examiners. *The Journal of Law, Economics, and Organization*, 37(3), 607–636.
- de Rassenfosse, G., & Jaffe, A.B. (2018). Are patent fees effective at weeding out low-quality patents? *Journal of Economics & Management Strategy*, 27(1), 134–148.
- Roth, J. (2022). Pretest with caution: Event-study estimates after testing for parallel trends. *American Economic Review: Insights*, 4(3), 305–322.
- Schankerman, M., & Schuett, F. (2022). Patent screening, innovation, and welfare. *The Review of Economic Studies*, 89(4), 2101–2148.
- Shao, P. (2018). The impact of the third amendment of patent law on patent acceptance and approval standards based on the empirical analysis. *Electronics Intellectual Property*, 12, 77–87. (in Chinese).
- Singh, K. (2022). Impact of patent (amendment) act, 2005 on Indian pharmaceutical industry. *Journal of Intellectual Property Rights*, 27(6), 397–414.
- Tagliatalata, J., & Barontini, R. (2024). SMEs and patents: Is it worth it? A longitudinal analysis of the patent-performance relationship. *Journal of Economics and*

- Business*, 128, 106147.
- Tao, F., Zhao, J., & Zhou, H. (2021). Does environmental regulation improve the quantity and quality of green innovation — Evidence from the target responsibility system of environmental protection. *China Industrial Economics*, 2, 136–154. (in Chinese).
- Wadho, W., & Chaudhry, A. (2018). Innovation and firm performance in developing countries: The case of Pakistani textile and apparel manufacturers. *Research Policy*, 47(7), 1283–1294.
- Wang, J. (2009, September 29). Understanding of the revised content of the third amendment to the Chinese Patent Law. *China Intellectual Property News*. http://www.iprchn.com/cipnews/news_content.aspx?newsId=13552 (in Chinese).
- Wen, J., & Zhang, S. (2018). Economic openness and China's international technological innovation — Empirical study based on provincial PCT international patent applications. *China Industrial Economics*, 11, 120–131. (in Chinese).
- Xu, K., & Wei, J. (2020). Third revision of the patent law, technology diffusion and firm value — Empirical evidence from China's manufacturing listed companies. *Journal of Shanxi University of Finance and Economics*, 42(9), 1–14. (in Chinese).
- Yang, W.N., & Yen, A.Y. (2009). The dragon gets new IP claws: The latest amendments to the Chinese patent law. *Intellectual Property & Technology Law Journal*, 21(5), 18.
- Zhang, J., Chen, Z., Yang, L., & Lin, Y. (2015). On evaluating China's innovation subsidy policy: Theory and evidence. *Economic Research Journal*, 50(10), 4–17 + 33. (in Chinese).
- Zhang, J., & Zheng, W. (2018). Has catch-up strategy of innovation inhibited the quality of China's patents? *Economic Research Journal*, 53(5), 28–41. (in Chinese).

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