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RESEARCH ARTICLE

Can Patent Quality Alleviates Information Asymmetry in Chinese Intellectual Property Market: Evidence From Auditing Field

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ABSTRACT Due to the lack of professional knowledge, auditing innovation quality has always been a big problem for auditors. Patent citation is a new and informative signal. We hope this signal can help auditors reduce the lack of professional knowledge and reduce the audit input of innovation quality. By examining Chinese non-financial firms between 2011 and 2019, we use patent citation as the proxy of patent quality and find that firms with higher patent quality have lower audit input at the same level of R&D expenditure. Further tests show that the signaling effect of patent quality is limited. Patent quality signals will work when the audited firm is a high-tech enterprise, or when the Key Audit Matters (KAMs) involve items such as R&D expenditures. But the auditor industry specialization can replace the influence of patent quality. Our results imply that auditors can use patent quality as a signal to reduce the difficulty of obtaining information and risk evaluation. Firms should focus on the quality of patents and display their innovation capabilities through the intellectual property (IP) market. China should strengthen the protection of private rights and continuously enhance the supporting mechanism of IP market.

INDEX TERMS China, audit input, patent quality, intellectual property market, information asymmetry, intermediary institutions.

I. INTRODUCTION

The main research question of this paper is whether the new and informative signal, citation frequency of a patent, can reduce audit input by alleviating information asymmetry due to auditors' lack of professional knowledge. The reason why we research this question is Chinese IP market is at the basic stage and not efficient enough, and we want to alleviate the information asymmetry of the IP market. Before entering our research topic, we need to give a simple introduction of the development background of China's IP market.

On September 22, 2021, China released the Outlines for Building a Powerful Country with Intellectual Property Rights (2021-2035) (hereinafter referred to as The Outline), in which it emphasizes the need to construct an intellectual property market operating mechanism that encourages innovation and development. This mechanism covers a creation mechanism and a supporting mechanism. The creation mechanism aims to "improve a high-quality, enterprise-led and market-oriented creation mechanism", that is, to guide market entities to give full play to the combined effects of patents, trademarks, copyrights, and other types of intellectual property (IP), and finally cultivate several world-class enterprises with strong IP competitiveness. The supporting system is to "establish a standardized, orderly and dynamic market operating mechanism" by improving the service level on IP agency, law, information and consultation, and supporting the development of value-added services such as appraisal, transaction, transformation, custody, investment and financing of IP assets.

Recently, China has made huge leaps forward in creation mechanism, that is, in enterprise-led research and

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development and innovation. According to the statistics of China National Intellectual Property Administration (CNIPA), there were 1.403 million invention patents applied and 0.53 million authorized in China in 2020. By the end of 2020, the number of valid invention patents in China was 3.058 million, of which 2.213 million are from China's mainland. Internationally, the World Intellectual Property Organization (WIPO) reports that in 2020, China filed 68,720 patents in 2020, outdistancing the United States and Japan, which filed 59,230 and 50,520, respectively.

However, China is still in its infancy in terms of supporting mechanism, which means that the IP market and its participants are still at the basic stage, which is the reason for information asymmetry. We explain this basic stage from two aspects: Chinese traditional culture and IP intermediary service level. Chinese traditional culture emphasizes the public attribute of knowledge and neglects the protection of private rights, that is, emphasizing dedication rather than personal interests. China has never had the protection of IP rights since ancient times. What has been in ancient China is only ''rulers' efforts to control the spread of ideas''. Even the ''copyright protection'' institution after the emergence of movable type printing in the Song Dynasty also served the needs of rulers to control speech, rather than consider the private interests. Until late Qing Dynasty, IP system was introduced into China [1], [2]. This special culture unlike western culture results in poor protection of IP rights. As for IP intermediary, compared with US, the development of IP services is largely limited by the level of national innovation and the quantity of high-quality IP. Therefore, for a long time, the IP service industry has been trapped in low-level patent agency services, and many high-level IP services lack sufficient social demand [3]. The valuation and liquidity of IP and the establishment of a transparent trading platform still have a long way to go [1]. Due to these two aspects, the information asymmetry between firms and external information users about innovation quality is severe in a developing country. The technological conditions and market systems related to patent protection and patent commercialization are obviously in an opaque and unstable state [4], [5].

There are usually two ways to reduce information asymmetry. One way is to force IP producers (the listed firms) to disclose more information about their patents. Another is to seek comments from professional information processors (the technical experts in our paper) in the relevant patent field. For example, we can estimate the stock value easily by analyst's rating, which can alleviate information asymmetry between the firm and investors. Thus, we hope to find a high-quality signal to help inexperienced information users (the auditors in our paper) make quick and accurate judgments.

Signaling Theory proposed by Spence in 1973 provides a theoretical basis for us to solve information asymmetry. Based on his theory, there is information asymmetry between different market participants. The information producer and processor can transmit signals to other information users in various ways to alleviate information asymmetry between them. In our context, the information users he says are auditors, and the signal the information processor may transmit is the patent citation. The reason why we choose patent citation as an identification signal is that patent citation is an excellent measure for evaluating innovation quality. Existing studies try to measure innovation quality in terms of R&D expenditure, patent quantity, and patent types [6]–[9]. With the development of computer and database technology, more complex citation information between patents is gradually mined out. Patent citation is more informative and can solve the deficiencies related to patent quantity [10]. Researches in the economic field have found that highly cited patents have more economic value and technological importance in the US market [10], [11]. However, unlike the US IP market, the Chinese traditional culture mitigates the willingness to apply for a patent and even if the patent is applied, the voices of ''patent bubble'' ''patent sleep'' ''innovation illusion'' and ''patent garbage'' are getting louder and louder in China. Therefore, the information level of patent quality is lower than that in western countries. Furthermore, Chinese local governments have fallen into an ''innovation cult'', leading to the phenomenon of ''quantity over quality'' [12]–[14]. In summary, signals that do well in the U.S. may not do well in China due to the reasons mentioned above. Therefore, whether the idea that using patent citation as a signal for IP intermediary is effective in China is our main issue that needs to be solved.

The IP intermediary such as accounting firms, law firms, and consulting firms mentioned in *The Outline* can reduce the cost of communication between firms and IP market and effectively improve the efficiency of resource allocation in IP market by providing professional services. We choose auditing intermediary to represent the IP intermediary as it is one of main intermediary in the capital market. IP market is an essential part of the capital market, but deals in more specialized intangible assets, patents, and so on [15]. Moreover, Non-auditing services in an important source of income for auditing intermediary. The Chinese Institute of Certified Public Account (CICPA) pointed out that it has become an international trend to expand the proportion of non-auditing services and improve and optimize the business structure of accounting firms in *Report on comprehensive evaluation and analysis of accounting firms in 2020*. The Chinese government has also put forward higher requirements for auditing intermediaries to ''enhance the level of self-discipline, fairness, and professionalism of accounting firms, and promote the Certified Public Accountant (CPA) industry to play its due role in strengthening financial regulation and enhancing the modernization of national governance system and ability''. As a result, the auditing intermediary should be an appropriate intermediary to examine the effect of patent citation in China. If the effect of patent citation in alleviating information asymmetry is well, the workload for auditing R&D expenditure and the firm risk will be lower, and thus the audit input will be lower.

Based on the above facts we discussed, this paper aims to solve the following two specific questions: First, will the increase in R&D expenditure lead to the increase in audit fee and audit delay? Second, the core question, can the patents quality referred to by auditors reduce their audit input required–to lower the audit fee and audit delay–when they are auditing R&D expenditure in China? For the first question, although the relationship between R&D expenditure and audit fee has already been studied in previous literature [9], [16], [17], the audit delay has not. Furthermore, the first question is the basis of the second question which is our key issue. We perform our empirical test based on statistics and econometrics. After basic regression, we find that an increase in R&D expenditure will raise the audit fee and audit delay; Under the same R&D expenditure level, the higher the patent quality, the lower the audit input is in China. Further tests show that the effect of patent quality is limited. Patent quality signals will work when the audited firm is a high-tech enterprise, or when the Key Audit Matters (KAMs) involve items such as R&D expenditures. But the auditor industry specialization can completely replace the influence of patent quality. The above conclusions are still valid after a series of robust tests.

The conclusions show that in limited contexts, the patent quality can now effectively alleviate the information asymmetry in the auditing field. The signal of patent quality is effective but not enough in China. Chinese traditional culture may account for this phenomenon. With the awareness of IP protection and the decrease in the difficulty of obtaining information about cited patents, the scale and effectiveness of IP market are improving. Firms with a higher patent quality have a better reputation in the IP market, signifying their high patent quality and innovation capability to the IP market. Auditors can refer to the assessment of a firm's patent quality from IP market to reduce their audit input, improve audit efficiency and provide better service to IP market entities. In this way, enterprises and intermediaries can promote each other and form a positive feedback cycle.

This study contributes to the extant literature in three ways. First, we propose and examine the signaling effect of patent quality in the auditing field under Chinese special background, providing suggestions to perfect the IP Market operation mechanism. Reasonable utilizing market forces to serve oneself and to transmit a signal that innovation capability is good to IP market participants can improve the efficiency in obtaining information in the practice field (audit field, credit rating field, etc.), and thus ameliorate the related work efficiency. Second, auditors usually view high-tech company as high-risk customer and ask for high audit fee, which impedes corporate innovation [18]. The result of this paper can encourage firms to improve their patent quality to transmit a positive signal to the outside IP market, reducing the fee paid to the intermediary. Third, the newer and better measure–citation frequency of patents–is used to evaluate the quality of innovations, which minimizes the defects of patent quantity and patent classification, and enriches the related research in the field of enterprise R&D and innovation.

The remainder of the paper is organized as follows. The second section is "Literature review and hypothesis development", the third section is "Research design", the fourth section is "Main empirical results", the fifth section is "Robustness test", and the sixth section is "Further analysis". Finally, we conclude in section "Conclusion".

II. LITERATURE REVIEW AND HYPOTHESIS DEVELOPMENT

The auditor's input can be measured by the cost and time it takes. Audit fee refers to the fee charged by the auditor to make up for the cost after providing services. The audit delay, a proxy of the auditing time, is the number of days starting from the balance sheet date to the audit report date [19]. Under the same conditions, the less cost and time auditors spend, the lower the audit input. As auditing is a service commodity, reducing cost and speeding up auditing are the critical issues concerned by the practice field and an essential source for the core competitiveness of an accounting firm.

The determinants of audit fee and audit delay, including audit cost, risk premium, and supply-demand relationship, are also hot topics in academia. In terms of audit cost and supply-demand relationship, many studies show that the larger the audited firm size, the higher the business complexity, thus the more the subsidiaries [20]–[23]. Or, the larger size of the accounting firm, the better accounting firm reputation [24]–[27], the higher audit fee auditor will charge. If the firm provides additional non-audit services (such as accounting services, bookkeeping services, tax services, management consulting services, etc.), they will also increase their audit fee [28], [29]. In terms of risk premium, the auditing risk can be divided into material misstatement risk and detection risk, with the former risk further divided into inherent risk and control risk. The higher the financial, operational, political, litigation, and other risks, the higher the probability of audit failure and loss. Therefore, auditors usually spend more time and effort auditing a firm with higher risk [20]–[22], [26], [30]. External information users generally pay more attention to listed firms that have received comment letters from regulatory authorities, so, under the pressure of reputation damage, litigation risk, and administrative punishment, auditors will expand auditing scope and spend more time and effort on these firms, which will boost audit fee and audit delay [31], [32].

Auditors need to devote their efforts and resources into auditing to overcome many risks. Firms with more innovations usually have higher degree of earning management and poor quality of financial statements, but high audit quality can effectively reduce management's manipulation of profits, which requires extra effort [18]. In the *Notes on Auditing risks of Annual Reports of Listed Firms*, CICPA repeatedly emphasizes that auditors should focus on the compliance of R&D expenditure, which also reflects the high auditing risk existing in R&D expenditure. Not only does higher R&D expenditure require more audit efforts in terms of scale, the classification of R&D expenditure, i.e., capitalization or expensing, as a common earning management tool used by management, can greatly increase auditing risk, and auditors will therefore charge higher audit fees [17].

From the perspective of audit cost, the increase of R&D expenditure is bound to promote the novelty and complexity of enterprise business. When auditors conduct financial auditing on R&D expenditures, intangible assets, and development expenditures, and conduct special auditing on patent, research project and high-tech enterprise certification, such as *The Special Auditing Report on the Economic Benefit of Patents* for XX Co., Ltd, *The Special Auditing (Verification) Report on R&D Expenses for XX Co., Ltd*, *Financial Acceptance Auditing Report on Projects (Research Subject) Carried out by XX Co., Ltd*, and *The R&D Pre-tax Deduction Verification Report for XX Co., Ltd*, more expertise, time and efforts are necessary. In order to make up for the personnel and material resources consumed in kinds of financial and special auditing, auditors will inevitably raise the charge. Additionally, due to the rising of audit workload, the audit will take more time, thus the overall audit duration will be longer [33].

From the perspective of risk premium, the R&D expenditure means the uncertainty of the firm, and new projects, though have high returns, is less probable to success [34]. Additionally, management will use capitalization or expensing of R&D expenditure for earnings management [17]. All of these can elevate the auditing risk for auditors, so they need to charge an additional risk compensation fee and prolong the audit duration [26], [30]. Based on the above analysis, we develop the first hypothesis:

H1: The more the R&D expenditure, the higher the audit fee and audit delay.

The auditing of R&D expenditure is a specialized work, which requires the auditor to have professional knowledge in the related field to effectively judge whether the amount presented in the financial report is relevant and reliable in all major aspects, and to sufficiently conduct kinds of special auditing and evaluation for intangible assets and patents. If auditors themselves do not have enough professional knowledge, they can hire experts in the related fields to carry out evaluations. However, with the surge of patent applications each year, experts may feel disqualified to review so many patents. If the time left to auditors is very limited, they may not be able to guarantee the audit quality when evaluating the item with complex valuation (such as derivatives, pensions, and goodwill) and making audit adjustments [35], [36], so auditors will employ many tools to speed up the auditing process. The corporate governance and internal control quality can be powerful tools for them. If the internal control system is perfect and efficient, and the corporate governance structure is balanced and reasonable, auditors can reduce the effort spent in auditing [37]–[42]. The frequency of cited patents mentioned in this paper can also play the same role in providing an external and reliable signal for auditors to identify the innovation quality.

Just as the patent is ranked first in IP right in *The Outline*, the patent citation information in the IP market may be the breakthrough to solve the problems of R&D expenditure auditing and special auditing. As the number of patent applications from company increases, the citation frequency of a paper has gradually become a standard for evaluating patent quality, which equals the academic evaluation system: the citation frequency of a paper and the impact factors (IF) of a journal are important standards for evaluating the quality of papers and journals. Similarly, the frequency of cited patents reflects the acceptance of this patent by other participants in IP market. Auditors can use this information as a preferable signal to reduce their audit input.

Spence [43] proposed the Signaling Theory that when there is information asymmetry between different market participants, the information producer and processor can transmit signals to other information users in various ways to alleviate information asymmetry between them. Signaling theory is a basic theory that is widely used in many disciplines, such as computer science, marketing, information science, patent, and auditing. In marketing filed, Li *et al.* [44] investigate how a physician can achieve economic success in the online consultation market from the perspective of signaling theory. In information management filed, Zhu and Wang [45] formulate the hypothesis that government microblog affects tourism market value by affecting consumers' emotion based on the signaling theory. In computer science field, Zhang *et al.* [46] proposed a novel method for crowd evaluating the security and trustworthiness of OSNs platforms based on signaling theory, which has been generally employed in the fields of economics and information management. In auditing field, Habib and Islam [47] use Signaling Theory to test whether auditors from a non - litigious environment are concerned about signaling their quality to the market by constraining clients' earnings management behavior; Casterella *et al.* [48] examine whether peer reviews conducted under the AICPA's self-regulatory model have been effective at signaling audit quality; Kitching [49] concludes that charities benefit simply from engaging a higher quality auditor from a signaling perspective. In patent field, Haeussler *et al.* [50] seek to contribute to the literature by presenting a framework in which the filing of a patent application is a signal which informs investors' expectations in terms of a venture's prospects. They find that the information generated during the patenting process is indeed useful to VCs. Hoenen *et al.* [51] hypothesize that patent activity has a signaling value that diminishes once information asymmetries between investors and funded firms lessen. They find that Patent activity has a significant signaling value that diminishes once information asymmetries are reduced. Hall *et al.* [10] and Lerner *et al.* [11] find that highly cited patents have more economic value and scientific importance, and citation frequency plays a better role than patent quantity in previous research. These studies all use

Signaling Theory as their basic theory. Some of them perform an empirical test on their research object. We follow previous literature, use Signaling theory as a basic theory, and perform an empirical test on the effect of patent citation in the auditing field.

Two key points–signal transmission and signal screening–are involved in the signal processing. In IP market, as the information concerning the patent citation is public information of CNIPA, the transmission and presentation of signals are natural; At the same time, because the signal is varied in quality, the screening of countless signals in IP market is of great necessity. Then, the question is raised: Can the information about patent citation be used as the signal of high quality?

How is the quality of signals of citation frequency of patents? Economic scholars take the lead in researching patent citation information. They find that highly cited patents have more economic value and scientific importance, and citation frequency play a better role than patent quantity in previous research [10], [11]. Frequently cited patents tend to be more likely sued, indicating that patent citation is related to their economic value [52]. Therefore, the patent citation rate is informative enough. On this basis, many scholars use citation frequency of patents to measure innovation quality of a firm. They found that R&D expenditure, patent quantity, and citation information of patents can positively impact the value of a firm and get an abnormal return in stock market [53], [54]. They also point out that patent citation has a much more significant effect in the pharmaceutical industry than in the computer industry [54]. The cited patent information has also become the reference in other evaluation fields. For example, Griffin *et al.* [55] find that companies with high innovation efficiency proxied by patent citation will gradually improve the firm's credit rating; Lee and Oh [56] find that the innovation degree is negatively related to the CDS of a firm. All these studies prove that citation information of patents can be used to predict the credit rating of a firm, which further confirm the informativity of the citation frequency of a patent.

As mentioned above, the citation frequency can denote the economic value and scientific and technological importance of the patent, which, compared with the number and classification of the patent in previous studies, can measure the patent quality better [10], [11], [54], [57]. Therefore, the citation frequency of patents can be used as a signal for auditors to make their judgements. However, there is no literature exploring the signaling effect of cited patent information in auditing field under Chinese background. Hence, we try to define the cited quantity as the evaluation criteria for patent quality in IP market. The higher the citation frequency of the patent, the more the patent is approved in the IP market, and the higher the patent quality, delivering a signal that the R&D and innovation invested by enterprises are more authentic and reliable, with strong innovation ability and low innovation risk, thus reducing the auditing risk of patents. By referring to the patent quality signal in IP market, the auditor can determine a high level of materiality for the audited firms with high quality, which will reduce the workload for auditing R&D expenditure and ultimately lower the audit fee. On the other hand, unlike the US IP market, the Chinese traditional culture emphasizes the public attribute of knowledge and neglects the protection of private rights, that is, emphasizing dedication rather than personal interests [1], [2]. Patent quality that is valid in the US market may not be valid in China. Thereout, we use a better signal–citation frequency to proxy patent quality to examine the signaling effect in China, and propose our second hypothesis:

H2: Under the same R&D expenditure level, firms with higher patent quality have lower audit fee and audit delay in China.

III. RESEARCH DESIGN

A. SAMPLE CONSTRUCTION

Our initial sample includes all Chinese A-share listed firms from 2011 to 2019. We obtain data from the CNRDS, CSMAR, and WIND Database, which is commonly used in economic research in China. There are tremendous studies that draw reliable conclusions using CNRDS, CSMAR, and WIND Database [1]–[3], [9], [12]–[15], [40], [41], [53]. These databases are directly relevant to our research objectives (i.e., patent and auditing). We obtain the latest patent code, applicant, and citation number of invention patents from the Chinese Research Data Service Platform (CNRDS), crawl patent classification information from Google Patent by Python and obtain auditing and financial data from the Chinese Stock Market and Accounting Research (CSMAR) database and the Wind Financial (WIND) Database.

Table 1 outlines the key sample selection procedures and the number of firms and observations after each key procedure.

TABLE 1. Sample selection procedure.

Procedures	Firm	Firm-year observations
Initial sample	2745	16111
Remove samples with missing values of variables	2729	15914
Excluding financial industry and the Special Treated (ST) firms	2670	15578
Winsorise all continuous variables at the 1% level in both tails	2670	15578

B. VARIABLES

1) PATENT QUALITY

We construct $PatentQuality_{it}$ as up to the statistical point t, the sum of the citation of all invention patents for firm i in recent five years as shown in the formula (1) below. $C_{in_{t-j}}$ is the adjusted number of citations received in year t by patent n_{t-j} ($n_{t-j} = 1 \ldots N_{t-j}$), issued to firm i in year t-j ($j = 1, 2, 3, 4, 5$), and Nt-j is the total number of patents issued to firm i in the year t-j that are cited in year t. In order to prevent enterprises from over-citing their own patents, we use the patent citation eliminating self-citation. Since in most industries, the duration of R&D expenditure benefits is about five years [58], we follow Gu [57] to calculate patent quality in a rolling calculation way with a window period of five years.

$$PatentQuality_{it} = \sum_{j=1}^{5} \sum_{n_{t-j}=1}^{N_{t-j}} C_{in_{t-j}} \tag{1}$$

2) CONTROL VARIABLES

For the control variables, we follow Xu and Wang [9], Gul, Hsu and Liu [23], and Zhang [59] to exclude alternative explanations. First, we include *Size*, *Lev*, *Roa*, *Growth*, *CFO* and *Soe* to control for size, financial, and income condition of a firm. Then, we include audit office and corporate governance characteristics such as *Big4*, *BoardSize*, and *Duel*. We also include *Opinion and FirstRatio* to control for external supervision characteristics. We include both firm and year fixed effects to control for firm and year-specific variation in audit input. The definitions of the variables are presented in Table 2.

TABLE 2. Variable description.

Type	Variable	Description
Independent variables	*AuditFee*	The natural logarithm of the audit fees.
	AuditDelay	The natural logarithm of the days between the balance sheet date and the audit report signing date.
Dependent variables	*RD*	The natural logarithm of the book value of R&D expenditure.
	PatentQuality	Following Gu [57].
Control variables	*Size*	The natural logarithm of the book value of total assets.
	Lev	Leverage, calculated by the book value of liability divided by the book value of total assets.
	Roa	Return on assets, calculated by net profit divided by the book value of total assets.
	Growth	The growth rate in sales revenue from the beginning of the year to the end of year.
	CFO	The cash flow from operation scaled by sales revenue.
	Big4	A dummy variable that equals 1 if the firm hires an international Big4 accounting firm and 0 otherwise.
	Opinion	A dummy variable that equals 1 if the audit opinion is unqualified opinion and 0 otherwise.
	FirstRatio	The percentage of shares held by the largest shareholder.
	Soe	A dummy variable that equals 1 if the firm is state-owned and 0 otherwise.
	BoardSize	The number of board directors.
	Duel	A dummy variable that equals 1 if the chairman is manager and 0 otherwise.

3) MODEL DESIGN

To test hypotheses 1 and 2, we estimate the linear regression (2) and (3). the dependent variables are audit fee and audit delay, the independent variables are R&D expenditure (*RD*) and *PatentQuality*, and the rest variables are control variables. According to hypothesis 1, we predict that α_1 will be positive; According to hypothesis 2, we predict that α_3 is negative.

$$AuditFee\ (AuditDelay) = \alpha_0 + \alpha_1 RD + \alpha_* \sum Controls + \varepsilon \tag{2}$$

$$AuditFee\ (AuditDelay) = \alpha_0 + \alpha_1 RD + \alpha_2 PatentQuality + \alpha_3 RD \times PatentQuality + \alpha_* \sum Controls + \varepsilon \tag{3}$$

IV. MAIN EMPIRICAL RESULTS

A. SUMMARY STATISTICS

Figure 1 presents the time trend of core variables (*RD*, *PatentQuality*, *AuditFee*, *AuditDelay*). The four core variables increase over time generally because of the development of science and technology. Firms are paying more attention to the R&D of new products, new technology, which increase the audit input. Additionally, we can see a sudden drop in audit fee and a leap in audit delay in 2019, because COVID-19 struck China and thus slowed down economy and delayed the auditing of annual report.

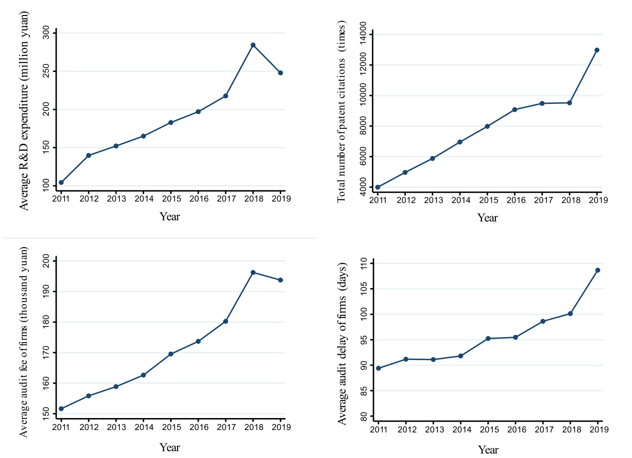

FIGURE 1. The time trend of core variables.

TABLE 3. Summary statistics.

Variable	No. of obs.	Mean	SD	Min	Median	Max
AuditFee	15578	13.747	0.704	12.429	13.641	16.369
AuditDelay	14436	4.527	0.227	3.526	4.585	4.771
RD	15578	17.747	1.461	13.366	17.741	21.668
PatentQuality	15578	2.289	1.212	1.000	2.000	7.500
Size	15474	22.092	1.259	19.899	21.902	26.061
Lever	15474	0.408	0.205	0.048	0.395	0.903
Roa	15474	4.464	6.100	-20.169	4.106	22.353
Growth	15472	0.087	0.241	-0.895	0.107	0.703
CFO	15474	0.080	0.150	-0.446	0.072	0.559
Big4	15474	0.051	0.219	0	0	1.000
Opinion	15578	0.970	0.172	0	1.000	1.000
FirstRatio	15473	34.345	14.545	8.700	32.590	73.800
Soe	15474	0.326	0.469	0	0	1.000
Boardsize	15474	8.922	1.997	3	9.000	19.000
Duel	15312	0.290	0.454	0	0	1.000

Table 3 presents the summary statistics of the variables used in the baseline analysis. The mean values of the dependent variables *AuditFee* and *AuditDelay* are very close to the median, indicating that the distribution of the two core dependent variables is symmetric, closer to the normal distribution, and the sample is representative. The mean value of the independent variable *PatentQuality* is 2.289, the maximum and minimum value of it is 7.5 and 1, indicating the citation frequency of patents has good variability and enough information, which meets the hypothesis of the optimal estimator of linear regression. The statistical results of variables in Table 3 are basically consistent with those of Xu and Wang [9]. The correlation coefficients of the variables above are all less than 0.5, indicating that the potential multicollinearity will not affect the conclusions.

B. R&D EXPENDITURE AND AUDIT INPUT

Table 4 presents the regression results obtained by measuring audit input using audit fee and audit delay. To conserve space, we do not report the coefficients on the control variables. Column (1) – (3) use audit fee, and Column (4) – (6) use audit delay. In Column (1) and (4), only core dependent and independent variables are added. In Column (2) – (3) and (5) – (6), control variables, year, firm, industry fixed effects are also added. The results show that no matter in what way, the regression coefficients of R&D expenditure (*RD*) is significantly positive, which support hypothesis 1: the more R&D expenditure, the more time and effort auditor spend in auditing, that is, the higher audit fee and audit delay.

TABLE 4. R&D expenditure and audit input.

Variable	(1) *AuditFee*	(2) *AuditFee*	(3) *AuditFee*	(4) *AuditDelay*	(5) *AuditDelay*	(6) *AuditDelay*
RD	0.113***	0.026***	0.027***	1.178***	0.241*	0.341***
	(31.180)	(6.289)	(10.005)	(4.137)	(1.769)	(3.211)
Constant	11.413***	5.472***	5.583***	68.792***	-19.718***	-28.651***
	(184.435)	(20.951)	(43.826)	(14.125)	(-3.817)	(-6.425)
Controls	No	Yes	Yes	No	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
Industry FE	No	No	Yes	No	No	Yes
No. of obs.	15,578	15,309	15,309	14,437	14,203	14,203
Adj. R2	0.453	0.577	0.585	0.054	0.090	0.094

Notes: Numbers in parentheses are t-statistics based on standard errors clustered by industry

***, ** and * denote statistical significance at the 1%, 5%, and 10% levels, respectively

C. THE MODERATING EFFECT OF PATENT QUALITY

Table 5 present the moderating effect of patent quality on R&D expenditure. The coefficient of R&D expenditure (*RD*) in all columns is significantly positive, still supporting hypothesis 1. Further, the coefficient of the interaction term (*RD* × *PatentQuality*) is significantly negative, indicating that *PatentQuality* has a negative moderating effect on auditors' efforts in R&D expenditure auditing, which supports hypothesis 2. We can see that the signal of patent citation is effective and can alleviate the information asymmetry in auditing field. In general, auditors usually view high-tech company as high-risk customer and ask for high audit fee, which impedes corporate innovation [18]. The economic significance of this result is the higher the patent quality of the company, the lower the auditing cost they will pay. It prompt firms to focus on the quality of patents and display their innovation capabilities and credibility by the signal of patent quality through the IP market and reduce the transaction cost.

V. ROBUSTNESS TEST

A. AN ALTERNATIVE MEASURE OF PATENT QUALITY

Hall, Jaffe and Trajtenberg [54] found that the citation frequency of patents in the computer, communication, and pharmaceutical industries was higher than that of patents in

TABLE 5. The moderating effect of patent quality.

	(1) *AuditFee*	(2) *AuditFee*	(3) *AuditDelay*	(4) *AuditDelay*
RD	0.113***	0.027***	0.015***	0.003*
	(26.501)	(4.169)	(7.254)	(1.879)
RD × *PatentQuality*	-0.006*	-0.006***	-0.003**	-0.003***
	(-1.882)	(-5.144)	(-2.195)	(-2.945)
PatentQuality	-0.003	-0.002	-0.008***	-0.008***
	(-0.261)	(-0.327)	(-4.113)	(-4.655)
Constant	11.418***	5.467***	4.223***	3.138***
	(131.764)	(12.315)	(112.268)	(42.578)
Controls	No	Yes	No	Yes
Year FE	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes
No. of obs.	15,578	15,309	14,426	14,202
Adj. R^2	0.453	0.577	0.048	0.080

Notes: Numbers in parentheses are t-statistics based on standard errors clustered by industry

***, ** and * denote statistical significance at the 1%, 5%, and 10% levels, respectively

other industries. In addition, they found that the citation number for earlier patents was higher than for newly granted patents. In order to solve this problem, we recalculate the patent quality following Gu [57], and the calculation method is as follows:

$$PatentQualityInd_{i,t} = \frac{\sum_{j=1}^{5} \frac{C_{i,t-j}}{InPCI_{H,t-j}}}{AveAsset_{i,t}} \tag{4}$$

$$InPCI_{H,t-j} = \frac{\sum_{i \in H}^{N} C_{i,t-j}}{N} \tag{5}$$

In the above formula, i denotes a single firm that in industry H, and N denotes the total number of firms in industry H. $PatentQualityInd_{i,t}$ denotes the patent citation degree of firm i in year t after industry adjustment;$C_{i,t-j}$ denotes the total adjusted citation number received in year t, issued to firm i in year $t-j$ ($j = 1, 2, 3, 4, 5$); $InPCI_{H,t-j}$ denotes the average industry citation number received in year t, issued to firm i in year $t-j$; $AveAsset_{i,t}$ denotes the average total assets of firm i in year t.

Table 6 presents the regression results of calculating patent quality based on the patent citation adjusted by industry. Column (1) is the regression results without industry adjustment, which provides a comparison for subsequent. Column (2) and (3) are the regression results after industry adjustment, which are entirely consistent with the results in Column (1). Table 7 changes the measurement of audit input from the audit fee to audit delay, and the regression results are consistent with the previous conclusion.

B. ADDITIONAL CONTROL VARIABLE

To control for some omitted variables that can impact audit input, we follow Dechow *et al.* [60] and Harp and Barnes [61] to measure earning management (*DA*) and internal control weakness (*ICW*). We also add two dummy variables auditor change (*AC*) and restatement (*Re*). Table 8 presents the regression results after adding control variables. Table 9 changes the measurement of audit input

TABLE 6. Alternative measure of patent quality based on audit fee.

	(1) *AuditFee*	(2) *AuditFee*	(3) *AuditDelay*
RD	0.027***	0.112***	0.026***
	(4.169)	(26.381)	(4.071)
RD × *PatentQuality*	-0.006***		
	(-5.144)		
PatentQuality	-0.002		
	(-0.327)		
RD × *PatentQualityInd*		-0.009***	-0.005**
		(-4.322)	(-2.694)
PatentQualityInd		0.014	-0.009
		(1.297)	(-1.126)
Constant	5.467***	11.417***	5.457***
	(12.315)	(150.331)	(12.297)
Controls	Yes	No	Yes
Year FE	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes
No. of obs.	15,309	15,242	15,309
Adj. R^2	0.577	0.453	0.578

Notes: Numbers in parentheses are t-statistics based on standard errors clustered by industry
***, ** and * denote statistical significance at the 1%, 5%, and 10% levels, respectively

TABLE 7. Alternative measure of patent quality based on audit delay.

	(1) *AuditDelay*	(2) *AuditDelay*	(3) *AuditDelay*
RD	0.003*	0.015***	0.004**
	(1.879)	(7.542)	(2.231)
RD × *PatentQuality*	-0.003***		
	(-2.945)		
PatentQuality	-0.008***		
	(-4.655)		
RD × *PatentQualityInd*		-0.006**	-0.004*
		(-2.554)	(-2.007)
PatentQualityInd		0.018***	-0.000
		(3.028)	(-0.016)
Constant	3.138***	4.206***	3.121***
	(42.578)	(124.620)	(41.626)
Controls	Yes	No	Yes
Year FE	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes
No. of obs.	14,202	14,426	14,202
Adj. R^2	0.080	0.048	0.079

Notes: Numbers in parentheses are t-statistics based on standard errors clustered by industry
***, ** and * denote statistical significance at the 1%, 5%, and 10% levels, respectively

from the audit fee to audit delay, and the regression results are consistent with the previous conclusion.

C. HIGH-DIMENSIONAL FIXED EFFECTS ESTIMATES

The main results may be affected by the characteristics of the industry and accounting firms that change over time, so we follow Hassan *et al.* [62] and use high-dimensional fixed effects to estimate based on the previous conclusions. Column (1) and (2) in Table 10 are the three-dimensional fixed effects results controlling time, accounting firm, and the firm itself. Column (3) and (4) are three-dimensional fixed effects result controlling time, industry, and firm itself. The interaction term *RD* × *PatentQuality* is significantly negative, which is consistent with the previous conclusion. Table 11 measures audit input by audit delay, and the results are consistent with the above.

D. FALSIFICATION TEST

Following Li *et al.* [63] and Cantoni *et al.* [64], we conduct a falsification test in this section. By randomly distributing the patent citation among each firm, the patent citation could not map to the patent quality of the original company. Then we used the randomly allocated sample to conduct 1000 regression analyses. If the coefficient of *RD* × *PatentQuality* is not significant, it indicates that the correlation between the two is not caused by other random factors. Figure 2 is the kernel density map of t-values after 1000 regressions, and the dotted line in the figure is the benchmark value. It can be seen from the figure that the t-value distribution of interaction terms after random allocation presents an inverted U-shape with symmetric axis 0, and most t-values are concentrated near 0. After comparing the benchmark t-values in Table 5, only a few t-values are less than −2.945 when we use audit delay to measure audit input. The falsification test indicates that most of the moderating effects of patent quality in a randomly

TABLE 8. Additional control variable based on audit fee.

	(1) *AuditFee*	(2) *AuditFee*	(3) *AuditFee*	(4) *AuditFee*	(5) *AuditFee*
RD	0.024***	0.027***	0.027***	0.022***	0.020***
	(5.258)	(4.178)	(4.161)	(3.847)	(3.542)
RD × *PatentQuality*	-0.003**	-0.006***	-0.006***	-0.004***	-0.003**
	(-2.889)	(-5.122)	(-5.142)	(-3.264)	(-2.208)
PatentQuality	0.000	-0.002	-0.002	0.001	0.001
	(0.035)	(-0.318)	(-0.322)	(0.181)	(0.144)
DA	-0.008				-0.004
	(-0.708)				(-0.307)
AC		-0.014**			-0.009
		(-2.889)			(-1.527)
Re			0.005*		0.003
			(2.071)		(1.392)
ICW				0.005	0.001
				(1.397)	(0.142)
Constant	4.947***	5.470***	5.470***	5.409***	5.009***
	(14.391)	(12.330)	(12.314)	(14.412)	(13.133)
Controls	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes	Yes
No. of obs.	14,067	15,309	15,309	14,447	12,993
Adj. R^2	0.608	0.578	0.577	0.573	0.591

Notes: Numbers in parentheses are t-statistics based on standard errors clustered by industry
***, ** and * denote statistical significance at the 1%, 5%, and 10% levels, respectively

TABLE 9. Additional control variable based on audit delay.

	(1) *AuditDelay*	(2) *AuditDelay*	(3) *AuditDelay*	(4) *AuditDelay*	(5) *AuditDelay*
RD	0.003*	0.003*	0.003*	0.001	0.004*
	(1.985)	(1.836)	(1.986)	(0.751)	(1.915)
RD × *PatentQuality*	-0.003***	-0.003***	-0.003***	-0.003***	-0.003***
	(-3.554)	(-2.973)	(-2.921)	(-3.329)	(-4.032)
PatentQuality	-0.007***	-0.008***	-0.008***	-0.007***	-0.006***
	(-3.741)	(-4.738)	(-4.697)	(-4.358)	(-3.022)
DA	-0.024***				-0.022***
	(-3.386)				(-3.043)
AC		0.009***			0.008**
		(4.329)			(2.900)
Re			-0.024***		-0.022***
			(-6.857)		(-5.180)
ICW				0.008**	0.003
				(2.613)	(0.974)
Constant	3.161***	3.136***	3.128***	3.195***	3.167***
	(42.925)	(43.157)	(41.803)	(57.471)	(39.090)
Controls	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes	Yes
No. of obs.	13,060	14,202	14,202	13,421	12,364
Adj. R^2	0.081	0.080	0.082	0.081	0.085

Notes: Numbers in parentheses are t-statistics based on standard errors clustered by industry
***, ** and * denote statistical significance at the 1%, 5%, and 10% levels, respectively

TABLE 10. High-dimensional fixed effects estimates based on audit fee.

Variable	(1) *AuditFee*	(2) *AuditFee*	(3) *AuditFee*	(4) *AuditFee*
RD	0.113***	0.028***	0.110***	0.024***
	(30.432)	(4.205)	(26.516)	(5.932)
RD × *PatentQuality*	-0.003*	-0.004***	-0.006**	-0.006***
	(-1.954)	(-3.317)	(-2.115)	(-5.791)
PatentQuality	-0.004	-0.003	-0.009	-0.004
	(-1.008)	(-0.484)	(-1.089)	(-0.742)
Constant	11.452***	5.118***	11.454***	5.433***
	(165.952)	(10.352)	(177.667)	(15.181)
Controls	Yes	No	Yes	No
Firm FE	Yes	Yes	Yes	Yes
Year × Auditor FE	Yes	Yes	No	No
Year × Industry FE	No	No	Yes	Yes
No. of obs.	15,474	15,309	15,578	15,309
Adj. R^2	0.363	0.588	0.465	0.583

Notes: Numbers in parentheses are t-statistics based on standard errors clustered by industry
***, ** and * denote statistical significance at the 1%, 5%, and 10% levels, respectively

TABLE 11. High-dimensional fixed effects estimates based on audit delay.

Variable	(1) *AuditDelay*	(2) *AuditDelay*	(3) *AuditDelay*	(4) *AuditDelay*
RD	0.014***	0.002	0.015***	0.005***
	(6.670)	(1.080)	(11.022)	(3.903)
RD × *PatentQuality*	-0.002*	-0.003**	-0.003***	-0.003***
	(-2.016)	(-2.827)	(-3.744)	(-3.692)
PatentQuality	-0.007***	-0.007***	-0.010***	-0.008***
	(-4.162)	(-4.078)	(-6.577)	(-4.230)
Constant	4.264***	3.165***	4.618***	3.423***
	(85.370)	(41.719)	(134.507)	(48.255)
Controls	Yes	No	Yes	No
Firm FE	Yes	Yes	Yes	Yes
Year × Auditor FE	Yes	Yes	No	No
Year × Industry FE	No	No	Yes	Yes
No. of obs.	14,340	14,202	14,426	14,202
Adj. R^2	0.056	0.088	0.052	0.081

Notes: Numbers in parentheses are t-statistics based on standard errors clustered by industry
***, ** and * denote statistical significance at the 1%, 5%, and 10% levels, respectively

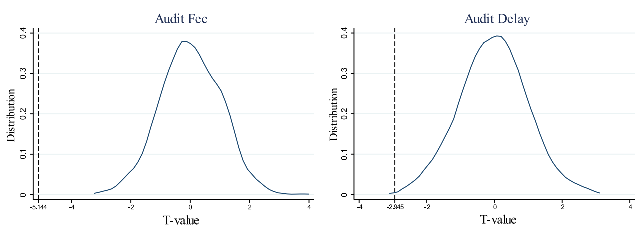

FIGURE 2. Falsification test.

constructed sample are not significant, so the moderating effect of patent quality on audit fee and audit delay is relatively robust, which indeed reduce the auditor's input.

VI. FURTHER ANALYSIS

To further clarify the signaling effect of patent quality, we try to explore whether the impact of patent quality on audit input will change from patent side and audit side after the main empirical test. The first part of the following analysis is from the patent side, i.e. the dependence of enterprise operation on R&D innovation; The latter two are from the audit side, i.e. the impact of professional judgements of auditors in KAMs, or the impact of industry expertise of auditors.

TABLE 12. High and new enterprise certification based on audit fee.

Variable	Authenticated		Unauthenticated	
	(1) *AuditFee*	(2) *AuditFee*	(3) *AuditFee*	(4) *AuditFee*
RD	0.086***	0.032***	0.159***	0.031***
	(11.600)	(4.164)	(15.123)	(3.344)
RD × *PatentQuality*	-0.012***	-0.009***	-0.001	-0.003
	(-3.911)	(-5.876)	(-0.267)	(-1.745)
PatentQuality	-0.007	-0.009	0.002	-0.000
	(-0.919)	(-1.458)	(0.106)	(-0.032)
Constant	12.150***	6.380***	10.460***	4.922***
	(96.342)	(7.352)	(51.135)	(13.913)
Controls	No	Yes	No	Yes
Year FE	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes
No. of obs.	6,069	5,924	9,509	9,385
Adj. R^2	0.398	0.514	0.480	0.593

Notes: Numbers in parentheses are t-statistics based on standard errors clustered by industry
***, ** and * denote statistical significance at the 1%, 5%, and 10% levels, respectively

A. THE INFLUENCE OF HIGH AND NEW TECHNOLOGY ENTERPRISES CERTIFICATION POLICY

For the high and new technology enterprises certificated by the Ministry of Science and Technology (MST) of PRC, innovation is the core competitiveness and key factor of future profitability. The top priority for auditors lies in the revenue auditing, which is often risky. In 2008, the MST issued the *Conditions and Measures on the Designation of High and New Technology Enterprises*. One of the conditions is that revenue from high and new technology products shall account of more than 60% of the annual gross revenues of the enterprises, so the revenue auditing for a high and new technology company demands more inputs and expertise. In the same year, CICPA issued the *Guidelines on Special Auditing for the Certification of High-tech Enterprises* (hereinafter referred to as *The Guidelines*) to regulate relevant issues, ensure audit quality and enhance financial information reliability. *The Guidelines* also emphasizes the auditing of patent-related information and the assurance of R&D expenditures and activities. In general, for these companies, auditors need to invest more in auditing R&D quality, operating revenue and undertake greater auditing risks. In this context, patent quality can serve as a signal for auditors to judge the auditing risk of high and new technology enterprises. Compared with companies with fewer R&D innovations, i.e. companies without high and new technology certification, patent quality can work better. Therefore, we obtain the certification information of high and new technology enterprises from the CSMAR database, and the statistics show that high and new technology enterprises account for about 40% of the total enterprises. The results of grouping tests for high and new enterprises are shown in Table 12 and 13. The moderating effect of patent quality is not significant for companies that have not been certificated as high and new technology enterprises. Instead, for certificated companies, the moderating effect of patent quality is significantly negative, shows that patent quality the signals can effectively alleviate the information asymmetry when auditors certificate and provide auditing services to high and new technology enterprises.

TABLE 13. High-tech enterprise certification based on audit delay.

Variable	Authenticated		Unauthenticated	
	(1)	(2)	(3)	(4)
	AuditDelay	*AuditDelay*	*AuditDelay*	*AuditDelay*
RD	0.010***	0.001	0.030***	0.018**
	(6.714)	(0.584)	(23.876)	(2.515)
RD × PatentQuality	-0.014**	-0.016**	-0.002	-0.003
	(-2.147)	(-2.799)	(-0.921)	(-0.458)
PatentQuality	0.013	0.015	-0.006***	-0.005
	(1.173)	(1.241)	(-4.500)	(-0.572)
Constant	4.334***	2.918***	3.952***	3.123***
	(155.999)	(27.328)	(156.422)	(14.599)
Controls	No	Yes	No	Yes
Year FE	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes
No. of obs.	5,327	5,213	9,099	8,989
Adj. R^2	0.026	0.065	0.059	0.083

Notes: Numbers in parentheses are t-statistics based on standard errors clustered by industry

***, ** and * denote statistical significance at the 1%, 5%, and 10% levels, respectively

B. THE ROLE OF KEY AUDIT MATTER

KAMs require auditors to use a lot of professional judgment, spend time, effort, and related audit resources and take more auditing risks and legal liability [65]–[67]. Auditors are more likely to disclose KAMs when the company faces higher litigation risk [68]. Therefore, when the KAMs include R&D, patents, etc., it indicates that auditors spend more effort and take more risks in making professional judgments on R&D expenditure's quality. We plan to start from the text of KAMs and manually screen out audit items related to patents, intangible assets, R&D expenditure, development expenditure, and other patent information, dividing the whole sample into two subsamples. If the firm has at least one KAMs related to the patent, the firm will be placed into the ''Include'' group; if not, it will be placed into the ''Not Include'' group. We obtained KAMs from the CNRDS database. The regression results are shown in Table 14. The first two columns and the last two columns take audit fee and audit delay as dependent variables, respectively. The coefficients of *RD* × *PatentQuality* in Column (1) and (3) are significantly negative, indicating that when auditors make professional judgments on KAMs related to patents and intangible assets, patent quality can be used as a signal and effectively reduce audit input. However, the coefficients of *RD* × *PatentQuality* in Column (2) and (4) are not significant, indicating that the value of patent quality information is little when auditors make professional judgments on other KAMs.

C. THE IMPACT OF AUDITOR INDUSTRY SPECIALISATION

Finally, auditor industry specialization means that the auditor has professional knowledge on a certain industry and should be familiar with the economic rule of it. Industry specialization helps the auditor make professional judgments about highly specialized R&D expenditures and patent information [69], [70] and may reduce their reliance on patent quality. According to the Upper Echelons Theory, due to the complexity of the external environment, managers make their strategic decisions through their personal lens. Similarly, the auditor's professional expertise, knowledge, information processing ability, and other characteristics will also affect the auditing process and professional judgment [71], [72]. The auditor without professional expertise is less familiar with the technological patents and may rely more on the IP

TABLE 14. The role of critical audit matter.

Variable	(1) Include	(2) Not Include	(3) Include	(4) Not Include
	AuditFee	*AuditFee*	*AuditDelay*	*AuditDelay*
RD	0.024*	-0.017	0.018**	0.011
	(1.853)	(-0.776)	(2.482)	(1.122)
RD × PatentQuality	-0.002**	0.004	-0.010**	0.004
	(-2.200)	(0.779)	(-2.204)	(1.252)
PatentQuality	0.016	-0.063	-0.005	-0.070
	(1.473)	(-0.738)	(-0.906)	(-0.824)
Constant	9.052***	5.471***	2.763***	1.712***
	(7.606)	(5.617)	(3.166)	(2.791)
Controls	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes
No. of obs.	1,772	3,394	1,963	3,681
Adj. R^2	0.258	0.231	0.088	0.081

Notes: Numbers in parentheses are t-statistics based on standard errors clustered by industry

***, ** and * denote statistical significance at the 1%, 5%, and 10% levels, respectively

TABLE 15. The impact of auditor industry specialization based on audit fee.

Variable	(1) Specialists (firm)	(2) Non-specialists (firm)	(3) Specialists (auditor)	(4) Non-specialists (auditor)
	AuditFee	*AuditFee*	*AuditFee*	*AuditFee*
RD	0.024**	0.033***	0.032***	0.038***
	(2.892)	(3.411)	(6.841)	(5.516)
RD × PatentQuality	-0.004	-0.007**	-0.003	-0.008***
	(-0.751)	(-2.156)	(-1.034)	(-3.635)
PatentQuality	0.001	-0.004	0.002	0.009
	(0.061)	(-0.829)	(0.118)	(0.870)
Constant	5.009***	6.483***	4.650***	6.611***
	(7.566)	(7.520)	(7.061)	(16.283)
Controls	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes
No. of obs.	5,071	4,913	4,958	5,026
Adj. R^2	0.520	0.434	0.489	0.459

Notes: Numbers in parentheses are t-statistics based on standard errors clustered by industry

***, ** and * denote statistical significance at the 1%, 5%, and 10% levels, respectively

TABLE 16. The impact of auditor industry specialization based on audit delay.

Variable	(1) Specialists (firm)	(2) Non-specialists (firm)	(3) Specialists (auditor)	(4) Non-specialists (auditor)
	AuditDelay	*AuditDelay*	*AuditDelay*	*AuditDelay*
RD	0.009**	0.013*	0.003	0.018*
	(2.256)	(2.047)	(0.715)	(1.996)
RD × PatentQuality	-0.000	-0.005**	-0.000	-0.006**
	(-0.018)	(-2.416)	(-0.025)	(-2.348)
PatentQuality	-0.002	-0.008	0.001	-0.017***
	(-0.181)	(-0.726)	(0.141)	(-3.595)
Constant	3.194***	2.076***	2.416***	2.274***
	(16.207)	(8.332)	(15.722)	(19.231)
Controls	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes
No. of obs.	4,561	4,443	4,465	4,539
Adj. R^2	0.074	0.078	0.079	0.085

Notes: Numbers in parentheses are t-statistics based on standard errors clustered by industry

***, ** and * denote statistical significance at the 1%, 5%, and 10% levels, respectively market evaluation to the firm. Therefore, we follow Cahan and Sun [69], using the industry market share method to estimate the auditor industry specialization and carrying out our research from two perspectives: the industry specialization of accounting firms and the industry specialization of auditors. We obtained data of auditor industry specialization from CNRDS database and divided them into two groups (with and without industry specialization) according to the median. The results of the subsample test are shown in Table 15 and Table 16. For accounting firms and auditors without industry specialization, the moderating effect of patent quality is significantly negative, indicating that patent quality the signal can effectively alleviate the lack of industry specialization of accounting firms and auditors and help to reduce audit input. For accounting firms and auditors with industry specialization, the moderating effect of patent quality is not significant, indicating that auditors with industry specialization are less reliant on the patent quality signal in making professional judgments. The influence of patent quality can be replaced by auditor industry specialization, which indicating that the signaling effect of patent quality is limited.

VII. CONCLUSION

With *The* Outline released on September 22, 2021 as the research background and non-financial firms in China's A-share market from 2011 to 2019 as the sample, given the special culture background of IP market in China, this paper takes auditing intermediary as the entry point for IP intermediary, and tries to explore how to alleviate the information asymmetry about firm's innovation quality in China. Theoretical analysis shows that auditors is expected to face a lot of information asymmetry when auditing the R&D expenditure and conducting special auditing due to the limitation of their professional ability. Auditors can utilize the citation information of the existing patents as a signal to check the condition of patents in IP market and employ that information to evaluate the quality of R&Ds, which can reduce their effort spent in auditing, and improve the audit efficiency. The empirical test shows that the signal of patent quality can effectively alleviate the information asymmetry and thus reduce the audit input. Under the same R&D expenditure level, firms that have higher patent quality have lower audit fee and audit delay. Further tests show that the effect of patent quality is limited. Patent quality signals will work when the audited firm is a high-tech enterprise, or when the Key Audit Matters (KAMs) involve items such as R&D expenditures. But the auditor industry specialization can completely replace the influence of patent quality. The Chinese traditional culture and immature IP market can account for this. The results mean that we should strengthen protection of private rights and continuously enhance the supporting mechanism of IP market.

To sum up, auditors usually view high-tech company as high-risk customer and ask for high audit fee, which impedes corporate innovation [18]. Our results prompt firms to focus on the quality of patents and display their innovation capabilities and credibility by the signal of patent quality through the IP market and reduce the transaction cost. However, we do not test or discriminate between alternative theories but only Signaling Theory. For future studies, the alternative explanations about the signaling effect of patent citation in the auditing field can be tested to overcome our limitations. Future research can also try to apply patent quality to the evaluation of other fields (like asset evaluation, company scoring, etc.) and examine the signaling effect of patent quality, which will learn more about China IP market and provide suggestions to perfect the IP Market operation mechanism.

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