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The blocking and transmission effects of lower level system in patent transaction - evidence from Chinese colleges and universities

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Conflicts and contradictions within the legal system may affect the effectiveness of law enforcement, but scholars have not conducted sufficient empirical research on the mechanism. Based on three periods of mixed cross-sectional data in 2015 and 2019 when the reform of patent transaction system in colleges and universities, which represents a quasi-natural experiment, has been carried out, this study adopted a difference-in-difference (DID) model to empirically analyze the efficiency of patent transactions. It was found that if the lower level system was not removed or revised in time when the higher level law had been revised, it would have a blocking effect on the implementation of the higher level law and thus make patent transaction less efficient. Furthermore, when the lower level system was revised accordingly, it would have a transmission effect on the implementation of the higher level law, which could promote its implementation. This basic conclusion remains valid after a series of robustness tests and can provide useful lessons for the systemic revision and organizing of laws, as well as the reform of the economic and social systems.

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Introduction

The recognition that law is a systematic existence is widely supported by the existing literature. Within the legal system, there are divisions between legal departments, between upper and lower laws, and between new and old laws. Harmony between these divisions is the pursuit of good law and is in itself good law. In a country's legal system, the status of the state organ that formulates legal norms is directly proportional to the hierarchy of legal authority. In China, for instance, laws enacted by the National People's Congress are positioned at a higher rank compared to administrative regulations formulated by the State Council. Subsequently, these hold a superior legal standing over regulations enacted by local governments. It remains undeniable, however, that there may be inconsistencies between different legal provisions on the same matter, and there are many conflicts and contradictions within the legal system due to different legislative subjects, themes, and timing, as well as the frequency of legal amendments. To solve this problem, the Legislation Law stipulates the levels of effectiveness for laws, departmental rules, and local regulations, as well as stipulating applicable rules such as new laws are superior to old laws and special laws are superior to general laws. This standardizes the effectiveness and modes of application for legislation at different levels and in different periods. Such rules solve legal conflicts to some extent; through good theoretical learning and legal training, legal workers can often find effective legal rules in conflicting legal texts to solve any problems of application.

As the development of economic and social system reform deepens, legal revision has become a way that the law actively adapts to society and guides social behavior. However, as mentioned above, the existence of law is systematic, and the revision of law tends to occur individually, while systematic revision is rare. This leads to changes in the upper law, but the lower law and system are not revised together (the opposite situation rarely happens because a lower legislative resolution contrary to the upper law would find it difficult to pass a legislative voting process). According to the rules for the application of law, of course, the upper law should be applied, not the lower law. However, for the public, such legal reasoning and conclusion cannot be easily and accurately judged through their own information, knowledge, and ability. Therefore, for organizations and individuals who have long complied with the lower law to arrange social activities, they may still choose to stick to the lower law or they may hesitate to pursue their activities. Conflicts and contradictions within the legal system may thus affect the results for the implementation of laws, but scholars have not yet conducted any effective empirical research on how this works.

Chinese studies on conflicts between laws have tended to focus on the discipline of law, with particular attention on the legal provisions themselves, and primarily use the analytical method of legal interpretation. The research results have generally been applied in the processing of judicial cases or the revision and compilation of laws. However, there is a lack of effective research on the effect of and mechanism for legal conflict at the macro level of society. In the law and policy fields related to science and technology, relevant research on system performance evaluation has been relatively mature due to the deep integration of research methods with management economics and statistics, and this maturity has laid the disciplinary foundations for the empirical research on conflicts in the legal system (Daw, Hatfield, 2018; Tang et al., 2022; Liu and Guo, 2023). The Law on Promoting the Transformation of Scientific and Technological Achievements, which was implemented in October 2015, reformed the patent transaction process system for colleges and universities. In April 2019, the Ministry of Finance issued the revised Interim Measures for the Management of State-owned Assets of Public Institutions.

According to the newly issued Law on Promoting the Transformation of Scientific and Technological Achievements, the measures make specific arrangements for the evaluation of university patent transactions and the filing of contracts. The successive introduction of these systems formed a short-term conflict between the lower and upper laws, which provides a typical sample for the study of the conflict in the legal system and legal effectiveness. Scholars have conducted many empirical studies on patent transaction in universities, and the establishment of relevant models for and measurement of the relevant variables also provide convenient conditions for the development of this study (Zhang et al., 2022; Kang et al., (2022)).

In this paper, mixed cross-section data from three periods before and after the change in the patent trading system in colleges and universities were used for empirical analysis of the patent trading efficiency using the mixed effects differential model (DID estimation model) to reveal the effect and mechanism of legal system conflicts on patent transaction. The theoretical contributions of this paper are threefold. First, it advances the study of law conflicts and contradictions from a theoretical and conceptual level to an empirical one. Second, by examining the legal inconsistencies in the reform of university patent transaction systems, it demonstrates the hindrance and conduction effects from lower-ranking systems to higher-ranking laws. It suggests that higher laws with greater legal efficacy should be integrated with lower laws for improved system performance. Third, this paper might be the first to elucidate the real-world impact of institutional change and conflict, applying the DID model twice in the same study. Practically, this paper highlights that systematic legal amendments and legislative technical reforms can mitigate system friction, enhancing social and economic benefits. This could serve as a valuable guide for formulating and implementing laws or policies in emerging economies undergoing reform.

Literature review and basic hypotheses

The phenomenon of conflicting laws has existed for a long time and has been widely studied by scholars, although this attention has largely focused on conflicts between the laws of different countries—that is, conflicts of law at the level of private international law (Sun, 2019; Briggs, 2019). Private international law, also known as "conflict law," emerged and developed on the basis of conflicts of international civil and commercial law. In essence, it seeks to determine the only applicable law for every foreign-related civil relationship and exclude the application of the laws of other countries (Du, 2019; Cotton, 2022). However, many legal conflicts also exist within the same legal domain.

It should be noted that although prior research and the present study are all aimed at resolving legal conflicts, the original research on legal conflicts in the field of international private law has focused on resolving those conflicts and mainly aimed to determine which country's law would be applicable in the studied situation. The research object is different from that of domestic legal conflicts, and the research depth and breadth cannot meet the needs of the development of the domestic social situation and legal system, so the reference significance is limited. Some scholars have pointed out that in the construction of the socialist legal system with Chinese characteristics, a large number of inconsistencies, conflicts, and contradictions exist among the laws due to the rapidity of legislation, and this trend is spreading and expanding (Wang, 2015). There are two kinds of domestic legal conflicts: one is a formal but not substantive conflict, which can be solved through the interpretation of the legal system; the other is a true conflict (Don, 2012). The true conflict between laws can

be recognized and resolved by the statutory state organ according to certain procedures and methods (e.g., the adjudication mechanism of Article 94 of the Legislation Law) (Don, 2014). However, "conflicts between new general provisions and old special provisions" (real conflicts) appear frequently and cannot be effectively solved even if the Legislation Law is applied (Zhou, 2021). Of course, there may also be interregional legal conflicts within the same country due to the differences in national and social systems (Jing, 2019), but that is not the object of this paper.

The conflict of laws has an impact on the effectiveness of law implementation, which results in the difficulty of judicial judgment, increases in the cost of compliance, and law operation discount. Conflicts of law can be demonstrated and resolved by judges, lawyers, prosecutors, and other professional groups in judicial trials, but this process is undoubtedly more difficult than when there is no such conflict. Huang (2016) pointed out that the courts often face great political and legal pressure to apply the rules of contradiction of upper-level and lower-level laws, which makes it difficult for the courts to fully normalize the application of this rule. More importantly, from the perspective of the sociology of law, many problems do not enter the judicial field in the process of implementation, and the public tends to shy away from or have no intention to seek help from the social function of justice (Li and Yan, 2013). Uncertainty about the right behavior under conflicting laws increases the cost of legal compliance. Especially in cases involving interactive laws such as administrative examination and approval, engagement between the administrative counterpart and the administrator is needed, and the difference in how the two understand the conflict further magnifies its impact.

The Law on Promoting the Transformation of Scientific and Technological Achievements issued in 2015 and the Interim Measures for the Management of State-owned Assets of Public Institutions before the revision make different provisions for the process of university patent transformation. According to the provisions of Article 18 of the Law on Promoting the Transformation of Scientific and Technological Achievements in 2015, the modes of patent transformation in universities and colleges include transfer, licensing, and price-fixing investment. In addition to the traditional methods of listing, trading, and auction in the technology exchange market, the transaction consideration can also be directly priced by agreement. To ensure fair pricing, the article also stipulates that the name of the relevant achievement and the transaction price should be publicized within the scope of the unit. However, even after this legislation was passed, the Interim Measures for the Management of State-owned Assets of Public Institutions, which was issued and implemented in 2006, remained in effect. State-funded patents obtained by colleges and universities are state-owned assets, and their management and disposal are subject to adjustment by these measures, according to which, patent disposal by colleges and universities can only be performed after price evaluation and approval.

In April 2019, the Ministry of Finance issued the revised Interim Measures on the Management of State-owned Assets of Public Institutions, which responded to the provisions of the Law on Promoting the Transformation of Scientific and Technological Achievements in 2015. These new measures added the right of institutions of higher learning to make autonomous decisions on whether to conduct asset evaluation in the transformation of scientific and technological achievements, and removed the requirement to submit to competent departments and financial departments for approval or filing. The university patent transformation process is a more specific arrangement, so there was a legal conflict between the upper and lower laws on university patent transaction from 2015 to 2019. According to jurisprudence, this kind of conflict is between the upper and lower laws, which is a "conflict in form but not in substance." Through the method of system interpretation, it can be concluded that the upper law should be applied. However, because universities and competent departments have a long tradition of following the practice of evaluating, pricing, and approving transactions in the transformation of scientific and technological achievements according to the original system, they have even formulated specific methods and normative documents for internal operation. The examination and approval of university patent transactions is also a typical "interactive" legal implementation, so the cognitive difference between the applicant and the approver further magnifies the impact of legal conflicts. If the lower law is not revised, it may lead to an increase in legal compliance costs and confusion in terms of legal application. This would not only fail to achieve the legislative goal of the upper law but may affect normal university patent trading activities and hinder the implementation of the upper law. Zhang (2019) pointed out that ensuring that state-owned assets are not lost is an important issue in the transaction of university patents. Huang (2023) highlighted the inherent contradiction between the state-owned assets system and patent transaction, which has a detrimental impact on the efficacy of university patent reform. Consequently, Huang called for the direct authorization of state-funded patents to individual inventors. Based on this analysis, this paper proposes two research hypotheses:

H1: After the implementation of the Law on Promoting the Transformation of Scientific and Technological Achievements in 2015, the efficiency of university patent transactions decreased.

H2: After the implementation of the Interim Measures for the Management of State-owned Assets of Public Institutions in 2019, the efficiency of university patent transactions was restored and improved.

Methods, variables, and data

Method selection. The traditional method for evaluating the effects of a policy is to set dummy variables and establish regression models (Cappelen et al., 2012; Zhang et al., 2015), but due to the lack of reference, it is impossible to distinguish whether the result is caused by the policies or the trend in the development of the objects themselves. In natural science experiments, to determine the influence of a certain factor, the object of study is often subjected to processing (i.e., the experimental group), while the other part of the object is not subjected to any processing (i.e., the control group). The difference between the two results can then be used as the basis for the analysis of the effect of the factor. However, research about the effect of patent transaction system reform on the efficiency of patent transactions cannot be artificially processed like an experiment in the natural sciences. However, similar to natural experiments, if a public policy or social system only affects some groups but has no impact or little impact on other groups, the former can be regarded as the experimental group and the latter as the control group (Wing et al., 2018). Furthermore, it would be possible to analyze the actual effect of the public policy or social system through the difference between the two.

The Law on Promoting the Transformation of Scientific and Technological Achievements issued by China at the end of 2015 reformed the transaction process for patents financed by the state. The system only targeted subjects such as universities and national scientific research institutions, while other economic subjects such as enterprises and individuals were not directly affected by the system. Therefore, referring to the studies of Liu, Zhao (2015), Delaney and Kearney (2016), and Latif, Miles (2020), Baker, et al. (2022); De and D'Haultfoeuille (2023), Roth, et al. (2023), this paper introduced enterprise patents as the

control group and university patents as the experimental group. The DID estimation model was used to study the processing effect of the system. At the same time, in 2019, the Ministry of Finance revised the evaluation and filing system for university patent trading in accordance with the Law on Promoting the Transformation of Scientific and Technological Achievements. This study, therefore, considered the social effects of two changes in the upper and lower systems. Three periods of mixed cross-section data before and after the change of the university patent trading system were, therefore, used for two differential estimations to determine the difference in the treatment effect brought about by two institutional reforms.

The patent transaction efficiency was the dependent variable. The patent transaction efficiency of enterprises before the implementation of the Law on Promoting the Transformation of Scientific and Technological Achievements is represented by y_{it}^q, and the patent transaction efficiency of universities is represented by y_{it}^g. The regression equations are as follows:

$$y_{it}^q = \beta_1 + \beta_2 x_{it}^q + \varepsilon_{it} \tag{1}$$

$$y_{it}^g = \beta_1 + \beta_2 x_{it}^g + \varepsilon_{it} \tag{2}$$

where x represents the relevant control variable, and ε_{it} is the random disturbance term. Similarly, after the implementation of the Law on Promoting the Transformation of Scientific and Technological Achievements, y_{jt}^q and y_{jt}^g represent the patent transaction efficiency of enterprises and universities, respectively. To analyze whether the patent transaction efficiency changed significantly before and after the implementation of the system, the latter is subtracted from the former, and the results are as follows:

$$\Delta y_{jt}^q = \Delta\beta_1 + \Delta\beta_2 x_{jt}^q \tag{3}$$

$$\Delta y_{jt}^g = \Delta\beta_1 + \Delta\beta_2 x_{jt}^g \tag{4}$$

These differences reflect the changes in the different groups before and after the implementation of the Law on Promoting the Transformation of Scientific and Technological Achievements. However, whether such changes are caused by the institutional reform or the influence of the object's own trends necessitates further analysis of the differences in the changes in the trends of the different groups, so the second difference is continued. The result obtained by subtracting Eq. (3) from Eq. (4) reflects both the time difference and the group difference brought about by policy implementation. The differential model can be expressed as follows:

$$y_{it} = \beta_1 + \beta_2 x_{it} + \beta_3 treated + \beta_4 post + \beta_5 DID + \varepsilon_{it} \tag{5}$$

where y_{it} represents the dependent variable, x_{it} represents the independent variable, *treated* is the subject dummy variable, *post* is the institutional dummy variable, and ε_{it} is the random disturbance item. *DID*, the product of the time and individual dummy variables, is the estimator of the differential difference, which serves as the basis for judging the impact of the implementation of the Law of Promoting the Transformation of Scientific and Technological Achievements on dependent variables. The policy of the Ministry of Finance in 2019 was treated in the same way. According to the estimation of the DID model, the results after differential analysis reflect not only the impact of institutional reform on patent transaction efficiency but also the impact of groups on transaction efficiency. It is thus necessary to focus on the coefficient of the interaction term—that is, the degree of influence of institutional reform on the transaction efficiency of colleges and universities.

Variable design.

(1) Explained variables. The explained variable in this paper is patent transaction efficiency. According to the Patent Law of the People's Republic of China, patents are categorized into three types: invention, utility model, and design. China conducts formal examination of utility model patents and design patents, which are disclosed on the authorization announcement date, and relevant technical information immediately enters public channels. The substantive examination system for early disclosure and delayed examination was, however, implemented for invention patents, which are disclosed before authorization, but from the date of disclosure, potential trading objects can know the relevant technical information through open channels. Due to the research type and evaluation system of universities and colleges, the patent achievements of universities are mainly inventions, so we selected invention patents as the research object and measured the efficiency of patent transactions by the time difference between patent publication and patent transaction filing. The larger the time difference, the lower the efficiency of the patent transaction.

(2) Explanatory variables. The explanatory variable in this paper is the estimate variable of differential difference, which is represented by the product of the dummy variable of time and the dummy variable of the subject. Because the subject of the patent rights has both exclusive ownership and joint ownership, the latter should be subjected to special treatment. Therefore, if the subject of patent rights is university, its value is 1; if the subject of patent rights is enterprise, its value is 0. Because the revised Law on Promoting the Transformation of Scientific and Technological Achievements was implemented in October 2015, the time variable takes the value of 1 after that date and 0 before that date. Similarly, in the second differential analysis, the value assigned after the implementation of the Interim Measures for the Management of State-owned Assets of Public Institutions in April 2019 is 1, and the value before the implementation is 0.

(3) Control variables. The control variables are patent transaction mode and patent individual information variables. Different transactions mean different levels of negotiation difficulty and transaction costs. According to the intensity of exclusivity, the transaction involved in a patent license can be divided into exclusive, sole and general licenses, and the effect of an exclusive license is similar to that of a patent transference. Shen et al. (2019) suggested that the total license income of colleges and universities depends on the market share of the products of licensees, so colleges and universities tend to license many enterprises. Transaction type is thus used as the control variable. Patent individual information variables include basic information, technology width, and technology value. Referring to the research by Boeing and Mueller (2019), the number of claims, the number of pages of the literature, and the number of applicants were selected as the main indicators for basic patent information. Referring to the study of Jiang et al. (2020), the number of IPC categories and the number of same families were taken as indicators to measure technological breadth and technological value. To sum up, the variables and measurement methods constructed in this paper are shown in Table 1.

Data description. The data used in this paper are from the Incopat database, and patent transaction data from 2013 to 2021

Table 1 Definitions of the variables.

Variable category	Variable name	Variable definition
Dependent variable	Transaction efficiency—Y	On a monthly basis, the time interval between patent publication and transaction, the shorter the interval, the higher the efficiency
Explanatory variable	Institutional reform—Post	The value is 0 before the system reform and 1 after the reform
	Control group—Treat	Enterprises are assigned a value of 0, and universities are assigned a value of 1
	Difference term—DID	DID = Treat × Post
Control variable	Transaction type—Monopoly	Transference and exclusive licenses are assigned a value of 3, sole licenses are assigned a value of 2, and general licenses are assigned a value of 1
	Number of claims—Right	The number of patent claims
	Number of pages—Document	The number of pages in the patent application document
	Number of applicants—Applicant	The number of patent applicants
	IPC classification number—IPC	The number of IPC classifications for patent applications
	Homologous number—Family	The number of patents filed in the same family

Table 2 Descriptive statistics.

	Stage 1 (N = 5902)				Stage 2 (N = 8259)			
Variable	Mean	SD	Min.	Max.	Mean	SD	Min.	Max.
Y	42.31	27.96	0.0300	188.3	48.93	33.04	0.0300	212.6
Post	0.620	0.480	0	1	0.560	0.500	0	1
Treat	0.370	0.480	0	1	0.370	0.480	0	1
Monopoly	2.710	0.680	1	3	2.520	0.840	1	3
Right	6.240	4.250	1	52	6.660	5.060	1	272
Document	9.130	4.050	1	50	9.540	4.230	1	44
Applicant	1.160	0.490	1	4	1.130	0.440	1	4
IPC	2.160	1.510	1	20	2.060	1.400	1	16
Family	2.140	1.180	1	18	2.110	1.170	1	27

were searched with the keywords "licenseyear" and "assignyear." The data in the period just covered before and after the two policy implementations, which constituted two sets of mixed panel data with six periods. According to the research purpose, the samples whose subjects are natural persons and foreigners were excluded, patents shared by universities and enterprises were excluded. After eliminating the samples with missing or extreme values for the main variables, a total of 10,487 effective samples were obtained, including 3674 samples between the two reforms, which were included in the empirical analysis in stages 1 and 2. Samples were classified as belonging to the university group or the enterprise group, of which 6427 were university group. The samples between the two reforms were included in the simulation and test of the DID model in two stages. Descriptive statistics are shown in Table 2. Overall, it takes approximately four years for the invention patents of Chinese enterprises and universities to be disclosed to the trading record. After the reform of the system in 2015, the average time spent on patent exchange increased, and further analysis of the difference and its causes should be reflected through the results of the differential analysis.

Empirical results and analysis

Basic regression analysis. The results of regression analysis are shown in Table 3; (1) is the first-phase regression model, and (3) is the second-phase regression model. To further enhance the robustness of the empirical results, control variables such as the transaction type, basic information, and technology information for the patent were added to the baseline results for regression; the results for models (1) and (3) are shown in (2) and (4), respectively. The interaction terms were significant at the level of 5% or 1%, and the regression coefficients of the first phase were positive, while those of the second phase were negative.

Table 3 Influence of transaction system reform on transaction efficiency.

	(1)	(2)	(3)	(4)
Variable	Y	Y	Y	Y
Post	2.713***	3.743***	10.815***	10.606***
	(2.81)	(3.96)	(11.90)	(11.70)
Treat	2.614**	−0.227	5.743***	5.741***
	(2.20)	(−0.19)	(5.01)	(5.02)
DID	3.129**	3.348**	−4.172***	−5.677***
	(2.04)	(2.24)	(−2.77)	(−3.80)
Control variables	No	Yes	No	Yes
Observations	5,902	5,902	8,259	8,259
R-squared	0.010	0.069	0.024	0.057
F	20.31	48.82	67.51	54.96

***, and ** are significant at the levels of 1%, and 5% respectively.

The regression results indicate that after the implementation of the first phase of the policy, there was a conflict between the lower and upper laws. The university patent exchange took longer—that is, the transaction efficiency was lower. After the implementation of the second phase of the policy, the lower law was consistent with the upper law, and the upper law was concretized. At this time, the time spent on university patent exchange fell rapidly compared with the efficiency under the legal conflict. The absolute value of the DID coefficient in the second period was higher than that in the first period, which indicates that the transaction efficiency of university patents in the second period also improved relative to before the reform, and the effect of the reform of the upper law appeared in the reform of the lower law. After adding various control variables, the regression results were

Table 4 Parallel trend test of DID.

	Stage 1 (N = 5919)	Stage 2 (N = 8259)
Variable	**Y**	**Y**
Pre2	1.630	5.563***
	(0.79)	(2.94)
Current	3.034	9.041***
	(1.31)	(4.91)
Post1	5.563***	3.000
	(3.44)	(1.52)
Post2	3.229*	−1.551
	(1.64)	(−1.10)
Post3	9.041***	5.081***
	(5.76)	(2.71)
Constant	37.783***	37.561***
	(26.19)	(31.77)
R-squared	0.0178	0.033

***, and * are significant at the levels of 1%, and 10% respectively.

Table 5 Results of the counterfactual test.

	(5)	(6)	(7)	(8)
Variable	**Y**	**Y**	**Y**	**Y**
Post	5.148***	4.024***	8.827***	7.468***
	(5.61)	(4.47)	(8.73)	(7.34)
Treat	4.278***	1.289	3.849***	3.494**
	(4.46)	(1.34)	(2.63)	(2.39)
DID	0.718	1.103	−0.100	−1.022
	(0.47)	(0.73)	(0.10)	(−0.61)
Control variable	No	Yes	No	Yes
Observations	5,902	5,902	8,259	8,259
R-squared	0.014	0.067	0.018	0.048
F	27.71	47.14	49.04	46.01

***, and ** are significant at the levels of 1%, and 5% respectively.

still significant, and the goodness of fit was improved, further increasing the reliability of the empirical conclusions.

Robustness test

Parallel trend hypothesis testing. The policy effect was an exogenous term, and there was no two-way causal relationship with the independent variable. The two-stage system reform only affected universities but not enterprises, so the differential model largely avoided data endogeneity problems caused by selective bias. At the same time, the application of the differential model has certain prerequisites for the data. In general, the treatment and control groups must meet the parallel trend assumption—that is, when the policy item is 0, there is no obvious difference between the two groups of data. Commonly used test methods include the graphic method, T-tests, and significance test of cross-terms (Kahn-Lang, Lang, 2020; Jin et al., 2022). A cross-term significance test was used in this paper. In the first stage DID model, 2015 was set as the year when the policy occurred—such as Current, Pre2 in 2013, Pre1 in 2014, and Post1 in 2016. The results of the parallel trend test are shown in Table 4; the regression results before 2015 (current) were close to 0 and not significant, which satisfies the hypothesis that the treatment and control groups have parallel trends before the policy implementation. The treatment group after 2015 showed a significant upward trend, which verified the results of the basic regression.

It should be noted that the second stage DID model did not satisfy the parallel trend hypothesis. The reverse analysis method was adopted to invert the samples before and after the second institutional revision. If the treatment and control groups need to meet the parallel trend hypothesis after the reform, the reverse observation was made to see whether there was a significant difference in the institutional effect before the reform. If there was a significant difference, the hypothesis is valid. The test results are shown in Table 4. After removing the samples in 2021, the hypothesis of the parallel trend was satisfied, and the regression result was still significant in the reverse analysis, so the original hypothesis was valid.

Counterfactual test. To test the robustness of the basic regression results and exclude the influence of other industrial policies or random factors, we referred to the studies of Bertoni et al. (2020) and Albright et al. (2021) and conducted a counterfactual test by advancing or lagging the time point of the policy intervention by one year. We further observed whether the regression coefficient of the differential term had significance. If the regression

coefficient of the differential term is significant, it means that the change in the explained variable is caused by other random factors; otherwise, it means that the change in the explained variable is an effect of the policy. Assuming that the implementation time for the two college patent transaction process reforms is one year ahead or one year behind, the regression model was rebuilt, and the results are shown in Table 5. The DID regression coefficients in the model (5–8) were not statistically significant, which indicates that the influence of other science and technology policies or random factors can be excluded, and the change in the patent transaction efficiency for universities resulted from the policy object studied in this paper.

Discussion

With university patents as the treatment group and enterprise patents as the control group, the application of two-stage DID method revealed that after the Law on Promoting the Transformation of Scientific and Technological Achievements (issued at the end of 2015) reformed the system for the patent transaction process of colleges and universities, their patent transaction efficiency did not improve as expected but showed a significant decline, contrary to the legislative purpose and theoretical presuppositions. During this period, the Interim Measures for the Management of State-owned Assets of Public Institutions had not been revised, which resulted in an inconsistency between the upper and lower laws. Although the Law on Promoting the Transformation of Scientific and Technological Achievements should be employed according to the applicable rules of law, universities were at a loss after the promulgation of the new law due to the inertia in long-standing operational rules and systems. After the Ministry of Finance released the revised Interim Measures on the Management of State-owned Assets of Public Institutions in April 2019, the efficiency of university patent transactions improved rapidly, not only surpassing the period before the implementation of the measures but also surpassing the period before the implementation of the Law on Promoting the Transformation of Scientific and Technological Achievements. After controlling for variables such as transaction type, technology breadth, and technology value, the above conclusion still holds.

This study empirically confirmed the existence of institutional conflict in the legal system and revealed the mechanism of institutional conflict: when the lower and upper laws are inconsistent, the lower law obstructs the implementation of the upper law and hinders the realization of its legislative purpose. When the lower law is subsequent to and consistent with the upper law, the lower law is conducive to the implementation of the upper law and promotes the realization of its legislative purpose. There

are four key policy implications of these results. First, the system is symbiotic: the upper and lower systems not only cooperate with and supplement each other but can also restrict and limit each other. When there are legal conflicts between the upper and lower systems, although the applicable rules of law can guide judicial adjudication, the public is often unable to determine the correct rules of behavior, which leads to an anomic social order and the failure of the legislative purpose. Second, the functional mechanism of the legal system must be considered when revising laws. When the upper law is revised, the lower laws and regulations should also be sorted out or amended promptly. Because the legislative bodies for the upper and lower laws are often inconsistent, however, the makers of lower law must pay prompt attention to changes in upper law and make legislative responses. Third, the connective legislation mechanism between the upper and lower laws is still lacking. Because the meeting times for the legislative organs at various levels are different in China due to the country's legislative mechanisms and organizational system, the procedures for setting the legislative agenda differ, so the immediate linkage between laws cannot be realized. In addition to the timely attention of the lower law–enacting body to the upper law, the body should also consider making arrangements for deliberation on the lower law at the same time as the revision of the upper law or establish a joint motion mechanism between the bodies enacting the upper and lower laws. Furthermore, the body should list the lower laws involved in the revision of the upper law to prompt the necessary revision. Fourth, the construction of the rule of law in grassroots units should be strengthened, and a unit legal consultant system should be established so when there is a conflict between the upper and lower laws, professional advisers can put forward advice on the application of law and guidance on codes of conduct to reduce the social cost and loss of benefits created by legal conflicts.

It should be noted that recent studies have identified potential biases in the application of the DID method and have suggested improvements (Baker et al., 2022; De Chaisemartin, D'Haultfoeuille (2023); Roth et al., 2023). Drawing from these studies, this paper selects "untreated individuals" as the control group, estimates the parallel trend over an extended period, and avoids staggered dynamic treatment effects to optimize the DID model and enhance the reliability of its conclusions. However, a key limitation is that the paper's core metric, transaction efficiency, does not account for patents that never undergo transactions. The lack of data on the commercialization of these patents hinders further expansive research.

Conclusions
This paper transforms the DID model commonly used in policy research, and applying it to the study of conflicts of law. It analyzed the property rights and trading system for scientific research achievements in China and highlighted the important role of the legal system in the revision of laws. It should, however, be pointed out that this paper studied only one form of the conflict between laws: conflicts between the upper and lower legal systems; in addition, there are legal conflicts of the same rank and conflicts within the same law, among others. There is still much to explore in the study of legal conflicts, as well as the use of big data statistics in legal research.

Data availability
The raw data and supporting information have been stored in the Science Data Bank. It is available at: https://doi.org/10.57760/sciencedb.18191.

References
Albright BB, Nasioudis D, Craig S, Moss HA, Latif NA, Ko EM, Haggerty AF (2021) Impact of medicaid expansion on women with gynecologic cancer: a difference-in-difference analysis. Am J Obstet Gynecol 224(2):195–e1. https://doi.org/10.1016/j.ajog.2020.08.007

Baker AC, Larcker DF, Wang CC (2022) How much should we trust staggered difference-in-differences estimates? J. Financial Econ 144(2):370–395. https://doi.org/10.1016/j.jfineco.2022.01.004

Bertoni D, Curzi D, Aletti G, Olper A (2020) Estimating the effects of agri-environmental measures using difference-in-difference coarsened exact matching. Food Policy 90:101790. https://doi.org/10.1016/j.foodpol.2019.101790

Boeing P, Mueller E (2019) Measuring China's patent quality: development and validation of ISR indices. China Econ Rev 57:101331. https://doi.org/10.1016/j.chieco.2019.101331

Briggs A (2019) The conflict of laws. Oxford University Press

Cappelen Å, Raknerud A, Rybalka M (2012) The effects of R&D tax credits on patenting and innovations. Res Policy 41(2):334–345. https://doi.org/10.1016/j.respol.2011.10.001

Cotton HM (2022) Private International Law or Conflict of Laws: Reflections on Roman Provincial Jurisdiction. In: Pogorelsky O (ed) Roman Rule and Jewish Life: Collected Papers. De Gruyter, Berlin, Boston, pp. 213–236. https://doi.org/10.1515/9783110770438-013

Daw JR, Hatfield LA (2018) Matching and regression to the mean in difference-in-differences analysis. Health Serv Res 53(6):4138–4156. https://doi.org/10.1111/1475-6773.12993

De Chaisemartin C, D'Haultfoeuille X (2023) Two-way fixed effects and differences-in-differences with heterogeneous treatment effects: a survey. Econ J 26(3):C1–C30. https://doi.org/10.1093/ectj/utac017

Delaney JA, Kearney TD (2016) Alternative student-based revenue streams for higher education institutions: a difference-in-difference analysis using guaranteed tuition policies. J High Educ 87(5):731–769. https://doi.org/10.1080/00221546.2016.11777420

Dong H (2012) A study of the classification of conflicts of law. J Guangzhou Univ. 11(07):26–32

Dong H (2014) Research on the problem of deciding the conflict of law. Law Sci 32(01):47–57. https://doi.org/10.16290/j.cnki.1674-5205.2014.01.020

Du T (2019) From "conflict of laws" to "sharing of laws": value reconstruction of private international law in the era of community of human destiny. Contemp law Rev 33(03):145–160

Huang Jinrong (2016) The application by chinese courts of the rules on solving conflict between higher and lower-level legislation and its limitations. Glob Law Rev 38(02):20–35

Huang Ning (2023) Conflict and coordination between the state-owned assets management system and the transformation system of scientific and technological achievements. Sci Technol Manag Res 43(16):22–30

Jiang N, Li J, Gu W (2020) Technology breadth, technology depth and knowledge transfer. Stud Sci Sci 38(09):1638–1646. https://doi.org/10.16192/j.cnki.1003-2053.2020.09.012

Jin Y, Wang W, Zhang J (2022) Property rights protection, political connections, and innovation of private enterprises: a study based on the introduction of property law. Ind Econ Res 03:86–99. https://doi.org/10.13269/j.cnki.ier.2022.03.004

Jing H (2019) Regional model law: as a way to resolve legal conflicts in the Guangdong-Hong Kong-Macao Greater Bay area. Jinan J 41(12):57–67

Kahn-Lang A, Lang K (2020) The promise and pitfalls of differences-in-differences: reflections on 16 and pregnant and other applications. J Bus Econ Stat 38(3):613–620. https://doi.org/10.1080/07350015.2018.1546591

Kang Y, Huang H, Zhang L, Huang W (2022) University-industry research collaborations and innovation of universities. J Quant Tech Econ 39(10):129–149. https://doi.org/10.13653/j.cnki.jqte.20220920.005

Latif E, Miles S (2020) The impact of assignments and quizzes on exam grades: a difference-in-difference approach. J Stat Educ 28(3):289–294. https://doi.org/10.1080/10691898.2020.1807429

Li X, Yan J (2013) Between secrecy and openness: the influence of bureaucratic organizations on the public's right to know under the circumstances of legal conflicts – an empirical study based on the experience of X department in M city. J Fuzhou Univ 27(06):51–57

Liu Y, Guo M (2023) The state-owned assets supervision system reform and the total factor productivity of state-owned enterprises. Econ Issues 45(01):80–86. https://doi.org/10.16011/j.cnki.jjwt.2023.01.001

Liu R, Zhao R (2015) Do national high-tech zones promote regional economic development?-a validation based on a double difference approach. J Manag World 8:30–38. https://doi.org/10.19744/j.cnki.11-1235/f.2015.08.005

Roth J, Sant'Anna PH, Bilinski A, Poe J (2023) What's trending in difference-in-differences? A synthesis of the recent econometrics literature. J Econometrics. https://doi.org/10.48550/arXiv.2201.01194

Shen H, Xu G, Huang C (2019) An empirical study of the factors influencing the exclusivity in university-firm technology licensing. Stud Sci Sci 37(06):1033–1042. https://doi.org/10.16192/j.cnki.1003-2053.2019.06.009

Sun S (2019) The logical system and legislative orientation of private international law. Law Rev 37(02):143–152. https://doi.org/10.13415/j.cnki.fxpl.2019.02.014

Tang L, Zhou L, Yang M (2022) Environmental regulation and enterprise green innovation: an empirical study based on the implementation of action plan of air pollution prevention and control. Stat Res 39(12):55–68. https://doi.org/10.19343/j.cnki.11-1302/c.2022.12.004

Wang C (2015) Development history and paradigm shift of conflict of laws in China. Acad Exploration 02:41–46

Wing C, Simon K, Bello-Gomez RA (2018) Designing difference in difference studies: best practices for public health policy research. Annu Rev Public Health 39:453–469. https://doi.org/10.1146/annurev-publhealth-040617-013507

Zhang B, Wu H, Gao D, Li J, Cui Z (2022) On university transferable patent recognition based on feature fusion. J Intell 41(09):159–165

Zhang J, Chen Z, Yang L-X, Xin F (2015) Evaluating China's innovation subsidy policy: theory and evidence. J Econ Res 50(10):4-17+33

Zhang W (2019) Economic analysis of mixed ownership of employee science & technology achievements. Soft Sci 33(05):51–54. https://doi.org/10.13956/j.ss.1001-8409.2019.05.10

Zhou W (2021) The legal regulation of information disclosure in public health emergencies -the proposal for amendment of article 38 of the law on the prevention and treatment of infectious diseases. Adm Law Rev 04:147–161

Author contributions
The author wrote and revised the manuscript. The author is fully and solely responsible for this manuscript.

Competing interests
The author declares no competing interests.

Ethical approval
This article does not contain any studies with human participants performed by the author.

Informed consent
Informed consent was not required as the study did not involve human participants.

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