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The Influencing Factors of University Teachers' Willingness to Disclose Inventions - Empirical Study from China

Xianyong ZHOU¹, Shicheng LI², Zhihong TANG³, Shuang CHEN⁴

Abstract

University teachers selectively disclosing inventions leads to a serious loss of high-value inventions in colleges, which seriously hinders the transformation process of university patents. To promote achievement transformation, Sichuan Province took the lead in carrying out the pilot reform of the mixed ownership of employee inventions in universities in China and encouraged professional inventors to transform achievements with property rights. However, whether university teachers are willing to disclose high-quality inventions to universities is unknown, and the stimulating effect of reforms on college teachers remains to be examined. From the perspective of the current situation of university teachers' willingness to disclose inventions in the process of the transformation of university patents, this paper selects teachers from seven universities in Sichuan Province, China, as the objects of the questionnaire, including Sichuan University and Southwest Jiaotong University. The study uses a structural equation model and draws the following conclusions: university teachers' characteristics, incentive mechanisms, and invention characteristics are positively related to their willingness to disclose inventions; enterprise activities are negatively related to university teachers' willingness to disclose inventions; and the influence of patent examination on the intention of invention disclosure is weak.

Keywords: willingness to disclose inventions, mixed ownership of employee inventions, transformation of university patents, university teachers.

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Introduction

Teachers selectively disclose inventions, and nearly 30% of colleges and universities in China face the problem of intellectual property loss (Zhao *et al.*, 2005), especially the serious loss of high-value inventions, which leads to the low commercial value of existing inventions in colleges and universities and increases the difficulty in implementing the transformation of university patents in colleges. In 2016, Sichuan Province took the lead in carrying out the pilot reform of the mixed ownership system of employee university patents in colleges, transforming “university ownership” into the “mixed ownership of employee inventions by inventors and the university” and encouraging inventors to transform achievements with property rights. However, it is unknown whether this reform has a positive effect on the disclosure of university teachers’ inventions.

Based on this, from the perspective of the current situation of the invention disclosure willingness of Chinese university teachers in the process of the transformation of university patents, this paper explores the factors that affect the invention disclosure willingness of teachers and their respective roles and then identifies the optimal path to improve the invention disclosure willingness of teachers to effectively promote the transformation of university patents.

Literature review

According to the current situation of teachers’ invention disclosure, scholars have analyzed the factors influencing the willingness of university teachers’ invention disclosure from the perspectives of teachers’ personal characteristics, incentive mechanisms, invention characteristics and technology transfer offices. Jensen *et al.* (2003) pointed out that more than half of the high-value inventions of university teachers in the United States were not disclosed to universities in 1990. Thursby *et al.* (2009) investigated 5811 patent samples of American professors as the first inventors and found that 26% of them were separately allocated to enterprises rather than universities; then, they analyzed the impact of patent features, university policies and inventor fields on teachers’ willingness to disclose inventions. Markman *et al.* (2006) conducted an empirical study on 23394 teachers in 52 universities and found that more than 33% of patents were privately licensed. Crespi *et al.* (2007) set up an evaluation model of academic ownership through the observation and analysis of samples from six Euro-pean countries. Approximately two-thirds of university research is not owned by universities but rather by private companies, which has become a very serious phenomenon in Europe and Canada. China’s domestic research is still in its infancy, and only Chen *et al.* (2014) and other scholars have conducted research from the perspective of the impact of university patent examinations on teachers’ willingness to disclose inventions.

Methodology

Teachers' personal characteristics and willingness to disclose inventions

Wentzel & Watkins (2002) pointed out that the academic creativity of university teachers is the internal root cause of the rapid development of patent creation activities. Associate professors and lecturers are more willing to disclose their inventions to schools because professors have neither the pressure of professional title evaluation nor more abundant social resources and relationship networks, so they are more likely to directly disclose inventions to enterprises or bypass universities and cooperate with enterprises (Owen & Powell, 2001; Siegel *et al.* 2003; Geuna & Muscio, 2009; Siegel *et al.* 2004). Based on this, the study proposes the following hypothesis:

H1: Teachers' personal characteristics positively affect their invention disclosure intention;

H1a: Associate professors and lecturers are more willing to disclose inventions to their schools than are professors; and

H1b: Teachers' scientific research and market development abilities are significantly related to their willingness to disclose inventions.

Incentive mechanism and willingness to disclose inventions

In the process of the transformation of university patents, the rights of profit sharing, transformation and priority assignment of inventors are difficult to implement. Some scholars believe that noneconomic benefits - compared to economic benefits - have a greater impact on the willingness of university teachers to disclose inventions (Chen, 2007; Siegel *et al.*, 2003; Chang *et al.*, 2015).

Siegel *et al.* (2003) believed the main motivation for university teachers to disclose their inventions is to publish papers to obtain the recognition of the scientific and technological community, while the secondary motivation is for their own economic benefits or to guarantee additional research funds, such as funds for graduate students or research equipment in the laboratory. Based on this, the study proposes the following hypothesis:

H2: The incentive mechanism has a positive effect on the intention to disclose inventions.

Invention features and willingness to disclose inventions

Many studies have highlighted the important impact of the type of invention and the stage of disclosure (Baldini, 2009). The inventions disclosed by teachers to universities are usually at the early stage of conceptualization or the stage of the laboratory model because teachers can obtain more academic honors from it, which has an important impact on the transformation of university patents

(Thursby & Kemp, 2002; Fong *et al.*, 2018). If university teachers disclose their mature inventions later, then they will obtain more economic benefits and less honor from the company (Thursby & Thursby, 2004). From the perspective of public interest, teachers' decisions on the type and stage of invention disclosure will have an important impact on the commercialization and technological development of inventions (Johnson & Liu, 2011; Wood, 2019)). Based on this, the study proposes the following hypothesis:

H3: Invention features positively affect the intention to disclose inventions;

H3a: Patent funding sources have a significant impact on teachers' willingness to disclose inventions; and

H3b: Inventions at different technical stages are significantly related to the influence of the intention to disclose inventions.

Corporate activities and willingness to disclose inventions

The willingness of university teachers to disclose inventions may be reduced by enterprises' funding of research and providing of license revenue (Cohen & Walsh, 2007).

Owen and Powel (2001) think that physics teachers' inventions are usually an improvement in the existing R&D process and products, so they are more inclined to establish contact with enterprises and exchange their own inventions for the opportunity to use other technologies and equipment. Such teachers' pay less attention to patent licensing and tend to cooperate with multiple enterprises. Markman *et al.* (2008) pointed out that when college teachers have more capital, skilled labor force and better office space, they are more likely to find market demand for their intellectual capital and establish new enterprises. Based on this, the study proposes the following hypothesis:

H4: Corporate activities negatively affect the willingness of university teachers to disclose inventions;

H4a: The more cooperation between university teachers and enterprises, the less willing they are to disclose their inventions to universities; and

H4b: There is a negative correlation between university teachers' willingness to disclose inventions and their entrepreneurship.

University patent examination and willingness to disclose inventions

Macho *et al.*, (2007) said that in the transformation of university patents, the information asymmetry of enterprises and university teachers is a key problem. The establishment of a university patent examination mechanism can solve the problem of information asymmetry for all parties.

Owen and Powell (2001) believed that the environment in which universities create review mechanisms is conducive to the diversified use of intellectual

property rights, which will maximize the disclosure rate of teachers' inventions. Chen *et al.* (2014) discussed the influence of patent examination on the invention disclosure of teaching staff and the patent licensing strategy of colleges and universities by building a game model. Patent examination has a negative impact on teachers' disclosure of inventions. Based on this, the study proposes the following hypothesis:

H5: University patent examination is positively related to the intention to disclose inventions.

Hypothesis summary and theoretical model

By reviewing and sorting out the relevant literature on the invention disclosure of university teachers, this chapter considers the concept of the elements and relevant relations of the invention disclosure of university teachers and puts forward the research hypotheses of this paper according to the theoretical hypothesis (Markman *et al.*, 2007; Boardman, 2014; Chen, *et al.*, 2014; Shao 2019)

Table 1: Research hypotheses

Hypothetical number	Hypothetical relation			Hypothetical direction
H1	Personal characteristics of teachers	→	Teachers' willingness to disclose inventions	
H1a	Teachers' title	→	Teachers' willingness to disclose inventions	-
H1c	Teachers' scientific research and market development abilities	→	Teachers' willingness to disclose inventions	+
H1d	Teachers' different research areas	→	Teachers' willingness to disclose inventions	+
H2	Incentive mechanism	→	Teachers' willingness to disclose inventions	+
H3	Invention features	→	Teachers' willingness to disclose inventions	
H3a	Patent funding sources	→	Teachers' willingness to disclose inventions	+
H3b	Different technical stages of the invention	→	Teachers' willingness to disclose inventions	+
H4	Corporate activities	→	Teachers' willingness to disclose inventions	

Hypothetical number	Hypothetical relation			Hypothetical direction
H4a	Collaboration between university teachers and companies	→	Teachers' willingness to disclose inventions	-
H4b	Entrepreneurship	→	Teachers' willingness to disclose inventions	-
H5	University patent examination	→	Teachers' willingness to disclose inventions	+

Results

Questionnaire design and reliability test

The research theme of this study is the issue of the disclosure of inventions by university teachers. Based on the research results of the disclosure of university teachers' inventions, as many items as possible related to the disclosure of inventions are collected (Chang *et al.*, 2016). At the same time, we also collected indirectly related entries of scholars such as on the influencing factors of college teachers' willingness to leave and start a business and measure teachers' research ability (Zhu *et al.*, 2017). After listening to the opinions of relevant experts for revision, the questionnaire entries were cleared by the experts and had high content validity.

This study used the SPSS 24 and Cronbach's alpha reliability coefficient to check the consistency of the survey questionnaire variables on each measurement item. According to the reliability analysis of the questionnaires, the Cronbach's alpha value of each index was greater than 0.7, which met the requirements of the reliability test, and the CITC was greater than 0.5, indicating that the measurement items met the research requirements. Deleting the Cronbach's alpha value of any question will not cause the value to increase, which also shows that the variable has good reliability.

Exploratory and confirmatory factor analyses

In the 50 reinvestigated samples, 44 items of the disclosure wish questionnaire were analyzed by exploratory factor analysis (EFA). Eight factors with eigenvalues greater than 1 were obtained by using maximum likelihood estimation. Considering the high correlation between the disclosure factors, we used geomin oblique rotation. Among the factors, content validity involves the item and the tested item. The questionnaire used in this study is based on a literature review that indicates the relationships or associations among variables. According to the results of the pre-survey, the wording and expression with double indicators are

further modified and improved to make them have content validity that meets the requirements. The focus of this research is structural validity, which refers to the ability of items to measure the measured variables. In this study, the structural validity of the scale is proven by exploratory factor analysis and testing through the collected data. According to the EFA analysis results of Mplus 7.4, each item of the questionnaire is reorganized and deleted. The final 8-factor structure and its standardized loadings are as follows.

The CMIN/DF is 1.24, which is less than 3, CFI and TLI are above 0.9, and RMSEA is 0.031, which is less than 0.08. All fitting indexes meet the general research standards, so it can be concluded that this model has a good matching moderation. In this study, a rigorous AVE method was used to evaluate differential validity. The root of each AVE factor must be greater than the correlation coefficient of each pair of variables, indicating that there is a differential validity between the factors. Each AVE factor root is larger than the standardized correlation coefficient outside the diagonal, so this study has differential validity, and the oblique lower triangle is the correlation coefficient.

Influence relation model and hypothesis test

Structural equation model analysis. In this study, we use Mplus 7.4 to analyze the structural equation model, and the relationship model of influencing factors is shown in *Figure 1*. From *Table 2*, it can be seen that CMIN/DF is 1.227, which is less than 3, CFI and TLI are above 0.9, SRMR is 0.036, which is less than 0.05, RMSEA is 0.045, which is less than 0.08, and all fitting indexes meet the general research standards. Therefore, it can be considered that this model has a good fit. According to the model analysis, market development ability (0.879), the market value of teacher invention (0.870) and the load coefficient of teachers' scientific research goal are large in the dimension of teacher characteristics; re-search reward (0.837), laboratory equipment (0.804), disposal right (0.811) and academic achievement award (0.803) are large in the dimension of the incentive mechanism; small and medium-sized tests in the dimension of patent characteristics are completed. The load coefficients of the later invention (0.886) and the later invention (0.796) after the completion of the pilot test are larger; the load coefficients of the enterprise R&D equipment (0.924), the enterprise R&D fund (0.802), the enterprise's efficient R&D team (0.8432) and the entrepreneurship (0.812) are larger in the enterprise activity dimension.

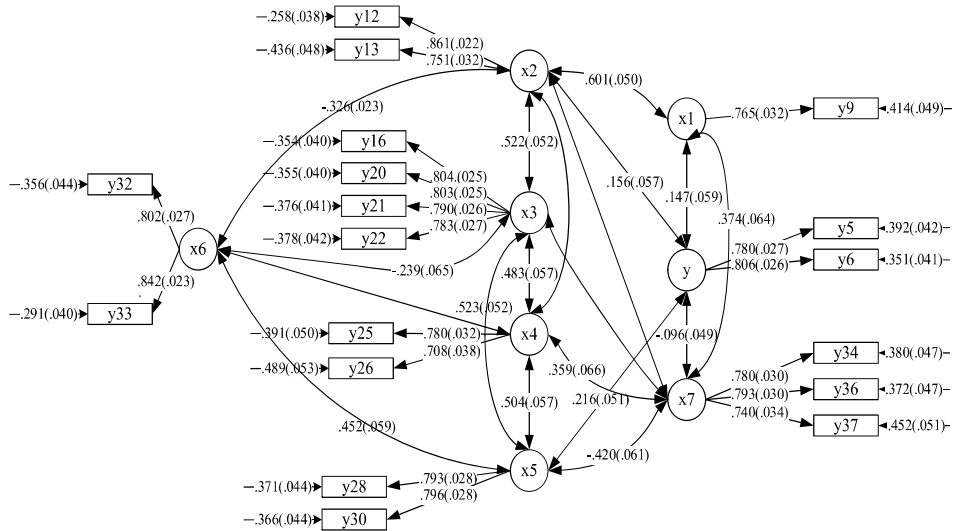


Figure 1: Structural equation models

Table 2: Results of the model fitting test

Model fitting index	Optimal standard value	Statistical value	Goodness of fit
CMIN	---	573.098	---
DF	---	467	---
CMIN/DF	<3	1.227	well
SRMR	<0.05	0.036	well
CFI	>0.9	0.980	well
TLI	>0.9	0.977	well
RMSEA	<0.08	0.045	well

Related hypothesis test. From Table 3 below, it can be seen that the teacher's market development ability (x1) has a significant positive impact ($\beta=0.147$, $P<0.05$) on the university teacher's intention to disclose inventions (y), and the hypothesis is tenable; the teacher's scientific research ability (x2) has a significant positive impact ($\beta=0.156$, $P<0.05$) on the university teacher's intention to disclose inventions (y), and the hypothesis is tenable; the university incentive mechanism (x3) has a significant positive impact on the university teacher's intention to disclose inventions (y). Willingness (y) ($\beta=0.328$, $P<0.05$) has a significant positive impact on the hypothesis; patent funding source x4 has a significant positive impact on the willingness to disclose inventions of university teachers (y) ($\beta=0.174$, $P<0.05$), and the hypothesis is established. Invention stage (x5) has a significant

positive impact on the willingness to disclose inventions of university teachers (y) ($\beta=0.216$, $P<0.05$), and the hypothesis is established; university teachers' and enterprises' industry cooperation (x6) has a significant negative impact on the willingness of university teachers to disclose inventions (y) ($\beta=-0.202$, $P<0.05$), assuming that it is tenable. University teachers' entrepreneurship (X7) has a significant negative impact on the willingness of university teachers to disclose inventions (y) ($\beta= -0.096$, $P<0.05$), assuming that it is tenable. From Table 3, we can see that the seven factors proposed in the scale have a significant negative impact on the willingness of university teachers to disclose inventions. Among these factors, the incentive mechanism has the most significant impact, and the rest are in the order of invention stage, cooperation with enterprises, source of patent funding, scientific research ability, market development ability and self-entrepreneurship.

Table 3: Test results of relevant assumptions

Path			Estimate	S.E.	Est./S.E.	p	Whether the hypothesis is supported
X1 (Market development ability)	→	Y (Willingness to disclose inventions)	0.147	0.059	2.498	0.012	yes
X2 (Scientific research ability)	→	Y (Willingness to disclose inventions)	0.156	0.057	2.727	0.006	yes
X3 (Incentive mechanism)	→	Y (Willingness to disclose inventions)	0.328	0.045	7.292	0.000	yes
X4 (Patent funding sources)	→	Y (Willingness to disclose inventions)	0.174	0.064	2.715	0.007	yes
X5 (Technical stages)	→	Y (Willingness to disclose inventions)	0.216	0.051	4.218	0.000	yes
X6 (Collaboration with companies)	→	Y (Willingness to disclose inventions)	-0.202	0.048	-4.235	0.000	yes
X7 (Entrepreneurship)	→	Y (Willingness to disclose inventions)	-0.096	0.049	-1.983	0.047	yes

Difference analysis

The result of one-way ANOVA shows that there is a significant difference ($F=21.341$, $P<0.05$) between the disclosure intentions of different titles of teachers. It is verified that there is a significant difference in the disclosure intentions of different titles of teachers in H1a. The disclosure willingness of associate professors (3.977) and lecturers (3.98) is higher than that of professors (2.956) and others (2.905).

The influence of patent examination on the willingness to disclose inventions in universities

This study shows that 53.36% of university teachers agree that there is an impure motivation for teachers' patent application, which indicates that more than half of them know that university teachers apply for "bubble patents" due to the evaluation of professional titles, and they think that universities should strengthen the process of patent examination. However, only 22.52% of these teachers think that patent examination will affect the willingness of university teachers to disclose inventions.

College teachers' attitude towards the mixed ownership of postuniversity patents

Perception of the impact of the mixed ownership of employee university patents. In 2015, Sichuan Province clearly proposed the reform of the ownership of employee inventions in colleges and universities. The perception of university teachers in Sichuan on the impact of the mixed ownership of employee university patents is shown as that, a total of 76.14% of the respondents believed that the mixed ownership of employee university patents could promote the achiever and his/her team to more actively promote the transformation of university patents; that is, mixed ownership would have a positive impact on the willingness to disclose inventions. University teachers' perception of this reform policy will affect their willingness to disclose inventions, and in practice, it will have an effective impact on the transformation behavior of university teachers.

Understanding and supporting the mixed ownership of employee university patents. As for the analysis of the college teachers' understanding of the mixed ownership system of employee university patents, only 23.87% of teachers have a general understanding of the mixed ownership system of employee university patents in Sichuan Province, and only 1.14% of them have a good understanding of it. After the author explained the relevant content of the mixed ownership of employee university patents in Sichuan Province, 46.59% of the teachers were neutral about the reform, and nearly half of the university teachers wanted to wait and see, indicating that the actual impact group of the policy still needs to be expanded; the total number of scientific researchers and university teachers who agreed and disagreed with the reform accounted for 46.59% and 6.82% of the university teachers, respectively. In summary, the research hypotheses of this study are verified as *Table 4*.

Table 4: Test results of the research hypotheses

Hypothetical number	Hypothetical relation			Hypothetical direction	Verification or not
		→			
H1	Personal characteristics of teachers	→	Teachers' willingness to disclose inventions		Yes
H1a	Teachers' title	→	Teachers' willingness to disclose inventions	-	Yes
H1c	Teachers' scientific research ability and market development ability	→	Teachers' willingness to disclose inventions	+	Yes
H1d	Teachers' different research areas	→	Teachers' willingness to disclose inventions	+	Yes
H2	Incentive mechanism	→	Teachers' willingness to disclose inventions	+	Yes
H3	Invention features	→	Teachers' willingness to disclose inventions		Yes
H3a	Patent funding sources	→	Teachers' willingness to disclose inventions	+	Yes
H3b	Different technical stages of the invention	→	Teachers' willingness to disclose inventions	+	Yes
H4	Corporate activities	→	Teachers' willingness to disclose inventions		Yes
H4a	Collaboration between university teachers and companies	→	Teachers' willingness to disclose inventions	-	Yes
H4b	Entrepreneurship	→	Teachers' willingness to disclose inventions	-	Yes
H5	University patent examination	→	Teachers' willingness to disclose inventions	+	No

Conclusions

In this study, a questionnaire survey of 253 university teachers in Sichuan Province, China, found that teachers' personal characteristics, incentive mechanisms, invention characteristics and enterprise activities have a significant impact on their willingness to disclose inventions, while university patent examinations and teachers' willingness to disclose inventions are negatively related. College teachers do not fully understand the reform of the mixed ownership system of post technology achievements in Sichuan Province, and nearly half of the teachers hold a wait-and-see attitude toward the reform. Therefore, in view of the status quo of university teachers' willingness to disclose inventions under the mixed ownership

system in Sichuan Province, the following countermeasures and suggestions are proposed.

1. Colleges and universities should improve the relevant measures to improve the enthusiasm of achievement transformation. The incentive mechanism and transformation management methods are quite different among colleges and universities. The relevant policies and measures should be improved, the transformation incentive of the university patents of college teachers should be stabilized, and it should be ensured that college teachers can obtain stable transformation benefits in a certain period of time. In addition, to ensure the noneconomic benefits of college teachers, we should take into account the desire of college teachers to achieve social worth and self-worth while safeguarding material benefits.

2. A specialized technology transfer department should be established. It is a professional work to transform the achievements of post science and technology in colleges and universities. The technology transfer offices of foreign colleges and universities are relatively mature. In the case that most colleges and universities in China lack professional institutions such as TTO, the inventor's disclosure intention is likely to face the problem of adverse selection; that is, low-quality inventions are disclosed to colleges and universities, and high-quality inventions are disclosed to institutions outside colleges or self-selected to start a business. China should establish professional technology transfer institutions.

3. Individuals should work together to push forward the reform of the mixed ownership system of post related university patents. The measures of colleges and universities play an important role in guiding the disclosure willingness of college teachers. Colleges and universities should create transformation space for teachers, guide teachers to connect with enterprises, and open channels for the transformation of university patents. In addition, colleges and universities should explore the establishment of market incentive mechanisms for incubation institutions and science and technology service practitioners. In this way, the multibody, multilink, and multistage cooperative mechanism and multi-guarantee mechanism are used to promote the transformation process of the university's job-based university patents.

4. The innovative development of all kinds of scientific research should continue to be developed. For basic research with a low possibility of transformation and application, different incentive mechanisms and evaluation mechanisms should be established for inventors and scientific researchers in university teachers so that the invention and transformation of talent can obtain material and nonmaterial rewards, and at the same time, there should be a relative incentive mechanism for talent committed to basic research.

5. The process of university transformation should be followed up, and the effect of policy implementation should be tested. From the independent experiment of Southwest Jiaotong University in 2010 to the expansion of the pilot reform of

the mixed ownership of employee university patents in Sichuan Province in 2018, the transformation of employee university patents in colleges and universities has not only the common features of commercialization and marketization but also the characteristics of each university's own attributes and management system. To advance the reform of employee invention ownership in colleges and universities so that achievements can be successfully transformed after disclosure, colleges and universities must explore effective transformation methods according to the actual situation.

Suggestions

To enhance higher education teachers' willingness of invention disclosure, the following suggestions are proposed according to above research results.

1. Expanding the effect of technological achievement made while holding position in higher education schools mixed ownership reform. Through various publicity and promotions inside and outside schools, the technological achievement made while holding position mixed ownership reform pilot is further increased to enhance the reform policy publicity and advice to higher education teachers, particularly science and engineering teachers so that more teachers are aware of and comprehend technological achievement made while holding position mixed ownership reform to enhance the willingness of invention disclosure.

2. Perfecting the complementary measures of technological achievement made while holding position mixed ownership reform in higher education schools. The trial platform construction in the technological achievement of higher education schools is gradually developed and enlarged when establishing specialized agencies, like professional technology transfer office (TTO), in higher education schools. Considering and exploring the promotion model for technological achievement made while holding position in higher education schools, the motivation of non-economic factors in higher education teachers' technological achievement output and transfer is further developed.

3. Exploring diverse transfer patterns of the technological achievement of higher education schools. When continuously encouraging and supporting higher education teachers' innovation and entrepreneurship, technological achievement transfer patterns of authorization, except for transfer of technological achievement ownership, is explored and technological achievement made while holding position mixed ownership reform is combined to promote higher education teachers' willingness of invention disclosure, aiming at higher education teachers' technological achievement transfer problems in China.

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