11. China's Patent Protection and Enterprise R&D Expenditure

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Based on data from the 2013 National Patent Survey of China, this chapter studies the causal relationship between patent protection and enterprise research and development (R&D) expenditure, and the moderating effect of patent motivation, patent accumulation and patent protection model selection on R&D-promoting effects. The results show: 1) compared with traditional market motives, strong patent protection is not associated with R&D expenditure for enterprises where motivation is administrative driven or strategy driven; 2) the scale effect of patent accumulation has a significant effect on R&D-promoting effects, while the facilitation effect of patent structure (represented by the proportion of invention patents in the total number of patents) on R&D is not significant; and 3) the use of administrative protection has a positive impact on R&D-promoting effects.

Motivation

As an important part of the intellectual property rights system, patent protection regulations are responsible for maintaining a balance between the dynamic efficiency brought about by incentivised innovation and the static inefficiency brought about by market monopolies (Nordhaus 1969; Klemperer 1990). Heated debates have been carried out in academia about the effect of patent protection on the ability of enterprises to increase research and development (R&D) expenditure and promote corporate innovation. Jaffe and Lerner (2006), Boldrin and Levine (2008), Burk and Lemley (2009) and other scholars have highlighted that patent protection does not promote innovation, but in fact may even serve to suppress it to a large degree; overzealous patent protection creates inefficiencies of monopoly in society and also limits knowledge sharing.

From a cross-border perspective, Helpman (1993) found that strict patent protections exacerbate the monopoly rights of property owners, weaken R&D incentives and slow the pace of global technological progress. Shapiro (2001) further shows that overly strong patent protection will increase the cost of learning for developing countries and is not conducive to technological catch-up. Scholars holding the opposite view acknowledge that there are some problems in the patent system, but, on the whole, it is beneficial for encouraging innovation (Gilbert 2011). Yang and

Maskus (2001) point out that, with the help of technology licensing and foreign direct investment (FDI), strengthening the protection of intellectual property rights is conducive to the transfer of production and technological innovation.

Based on these academic arguments, it appears that there is great theoretical value and practical significance in discussing the innovation promotion effects of patent protection. Through the construction of an intellectual property protection index, Ginarte and Park (1997) found that strict protection of intellectual property rights improves innovation and development around the world. Kanwar and Evenson (2009) and Chen and Puttitanun (2005) used cross-border macroeconomic data to investigate the effects of a country's patent protection on its R&D expenditure and innovation output, and found a positive correlation between them. Based on micro data, Mansfield (1986) points out that the impact of patent protection on enterprise R&D varies by industry. Yin et al. (2013) examined mechanisms via which enhanced protection of intellectual property rights serves to promote innovation output in a host country—either through increasing R&D expenditure or through foreign technology spillovers—and found that the mechanism to promote R&D input was significant.

The existing research has important referential value for understanding the effects of patent protection, but there are still many gaps in the literature. Whether through using simultaneous equations or using the lag phase of the level of patent protection (Chen and Puttitanun 2005; Kanwar and Evenson 2009) to analyse the relationship between patent protection and innovation, studies so far have not handled the endogeneity problem well. The degree of patent protection has a self-correlation and, although empirical strategies can reduce the endogeneity problem somewhat, resulting in a two-way causal relationship, the policy effect may be influenced by correlated unobservable factors such that a convincing causal relationship cannot be fully rendered. From a research design and data information perspective, a survey questionnaire offers a better way to avoid two-way causality and, at the same time, isolate the effect of patent protection on enhancing R&D. In the survey, one can ask enterprises questions such as: 'If patent protection is enhanced, will you increase R&D expenditure?' This retrieves first-hand research data. However, because such methods usually have a high implementation cost and time requirement, there have been few attempts in the United States, Europe, Japan, South Korea or other countries to investigate innovation and national patent protection through surveys. We have also not yet found any international literature on the effect of patent protection on innovation that uses survey data as its main subject for analysis.

In this regard, with assistance from the State Intellectual Property Office of China (SIPO), which organised a nationwide large-scale patent survey platform, this chapter uses a unique patent survey dataset from China to study the innovation promotion effects of patent protection. Our goal is to better understand the causal effects of patent protection on innovation and the heterogeneity effects among firms with different motivation, patent structure and protection approaches.

This chapter enriches the existing literature in two ways: first, it identifies the role of patent protection in causally enhancing enterprise R&D expenditure, based on the question proposed in the questionnaire about whether the strength of patent protection impacts on corporate R&D expenditure; and second, based on patent motive, patent structure and protection approaches, it explains the structural differences in the effects of strong patent protection on R&D promotion in enterprises with different characteristics and innovation activities. This research will therefore attempt to provide the scientific basis for strengthening patent protection policies in China. At the same time, it will provide a useful reference for enterprises to give full play to the facilitation effect of strong patent protection on innovation. The rest of this chapter is structured as follows: section two discusses research design, section three illustrates the empirical results and section four presents conclusions and policy suggestions.

Research questions and design

The innovation incentive effect of patent protection is influenced by a country's economic development, technology accumulation and national policy (Maskus 2000; Chen and Puttitanun 2005). For innovation latecomer countries, it might be helpful to use the patent system to stimulate innovation for economic transformation. Based on accumulated theories and market practices from developed economies, strong patent protection is linked with enhanced technology appropriability[1] and increased innovation-derived income, and thereby incentives are offered towards encouraging greater corporate R&D. The related incentive effects of patent protection can, however, fall or shift more categorically as a result of certain factors. Maskus (2000), for example, pointed out that the strength of patent protection and economic development exists in a U-shaped relationship in that only when per capita income reaches the middle-income development level will the facilitation effect of intellectual property protection be notably manifested. Before reaching that income level, the increase in patent protection intensity may have an uncertain effect on economic growth and R&D expenditure. Similarly, Chen and Puttitanun (2005) show that a country's patent protections depend on the level of non-monotonic development first decreasing, then increasing, which is determined by the trade-off between encouraging domestic innovation and imitating foreign technologies. Therefore, we need to study whether patent protection will promote innovation in enterprises; but we also need to examine the heterogeneous effect under different situations.

1 Technology appropriability can be defined as the ability of an innovator to profit from innovation or to internalise the benefits of innovation after solving technical-level issues in technological innovation.

The perspective of strategic connections between the creation, application, protection and management of intellectual property rights of enterprises, and the activities that affect their innovation process, suggests that such moderate factors should at least include the motivation in applying for a patent, the size and quality of the patent and the approach taken to protect patent rights. Accordingly, we arrive at three hypotheses.

Hypothesis 1

Differences in motivations for applying for or maintaining a patent will have different effects on R&D promotion.

Policy-driven and strategic market motivations will, for example, reduce the incentive effect of patent protection. Lin (2003) argued that the Chinese Government is accustomed to allocating resources through administrative authority to enterprises that have been given priority to develop, and to push for reform through administrative orders. When it comes to patents, government policy also has a strong influence on the behaviour of enterprises. When an enterprise submits an application for a patent, but does not intend to commercialise that patent and instead is motivated to acquire some qualification or to meet rigid government requirements, this will inevitably reduce the incentive effect on R&D of strong patent protection. In addition, with the enhancement of patent tools under market competition, the patent system will also become alienated. Research by Harabi (1995), Arundel (1995), Cohen and Goto (2002) and Blind et al. (2006) has shown that, in a competitive market environment, when enterprises apply for and maintain patents, this is not limited to using patents to expand the market, protect innovation, prevent technology from being imitated or other traditional functions. Enterprises driven by strategic 'non-implementation' patent motivations may seek to block competitors, promote and enhance their corporate image or create patent thicket standards,[2] and so on. Compared with traditional patent enforcement motives (such as the industrial use of patents), non-implementation motives place more emphasis on outcomes such as patent advocacy, access to bargaining chips and other strategic tools, and these may serve to inhibit the facilitative effect of patent protection on R&D development.

Hypothesis 2

The number of patents and their structural quality will be positively correlated with the facilitation effect of patent protection on R&D.

2 Patent thicket refers to the scenario in which firms need to acquire access to dozens, hundreds or even thousands of overlapping patents to actually commercialise new technology.

The number of patents is an important indicator of innovation ability. With the growth of patent accumulation, enterprises can obtain more favourable market competition, status, benefits of scale in research costs and prospectively higher operational profits, and thus maintain a virtuous cycle between the scale of patent numbers and sustainable R&D innovation. Patent structure refers to the proportion of invention patents, utility models and designs.[3] Research by Kim et al. (2012) found that the utility model system is an effective learning process during the technological catch-up phase. Through a historical overview, Maskus and McDaniel (1999) also found that during the process of technological catch-up in Japan, the utility model system brought about by technology spillover effects was significant. It is, however, obvious that the utility model is of lower quality than an invention patent and is not conducive to enterprises that are trying to reach the technological innovation frontier. Regarding this point, research by Kim et al. (2012) and Beneito (2006) demonstrated that if an enterprise wants to realise higher technical abilities, it should invest in invention patents and not utility models. Accordingly, we infer that the optimisation of the enterprise's patent structure (that is, a higher proportion of invention patents among all patents) will bring about a greater incentivising effect on R&D.

Hypothesis 3

If enterprises can utilise (administrative and judicial) protection systems to establish and enforce patent protection rights, the positive effect of patents on R&D will be more significant.

China's patent protection system is unique in having a 'double-track' feature via which enterprises can choose either administrative protection or judicial protection to carry out their protection rights. Although there is still some controversy in academic circles about which of the two should be dominant, the patent-related community generally accepts the relative advantages and complementarities of the two. As a private right, patent rights support legal institutional protection, while administrative enforcement influences the cost of enforcing patent infringement and is characterised by being simple, fast and efficient. A sound system of administrative enforcement can substantially shift the cost of patent infringement while significantly reducing the cost of having protection rights. In this regard, we expect that if companies can make full use of both mechanisms of protection then strengthening patent protection will have a greater effect on R&D growth.

3 There are three types of patent in China: invention patents, utility models and designs. Unlike invention patents, utility models and designs require no substantive examination at the patent office for them to be granted.

We test these three hypotheses using the National Patent Survey dataset from the most recent such survey, in 2013.[4] The nationwide survey has been carried out annually since 2008. The survey sample frame for 2013 was based on domestic patents granted in 2012. Sampling proportional to size methodology is used, supplemented by quota sampling. The sample frame for the 2013 survey included 777,308 patents, and the survey covered 65 cities in 26 provinces (including autonomous regions and municipalities). In 2013, there were 11,141 patentees and 9,161 enterprises in the survey; 33,667 patents were selected, of which 22,615 were corporate patents. The final response rate was 87.7 per cent, of which 93.7 per cent were valid questionnaires.

The survey itself examined whether the impact of patent protection is related to R&D expenditure, via the following question from the Enterprise Questionnaire of the 2013 National Patent Survey: 'What is the impact on your R&D expenditure if patent protection is enhanced?' Response options included: 'Increased R&D expenditure due to increased protection', 'Reduced R&D expenditure with enhanced protection', 'No significant impact' and 'Unclear'. The survey also asked a range of questions that would elicit information to help shed light on the variability of policy effects (discussed in detail later), as well as variables that reflect the basic characteristics of the surveyed enterprise, such as location, ownership, size, corporate qualifications (that is, whether it is an intellectual property enterprise recognised by the government at the provincial level or above, whether it is a high-tech enterprise, whether it is a central government–affiliated enterprise), and so on.

We used the multiple regression method to test whether hypotheses 1–3 are valid. Since the explanatory variable is a rank variable that reflects the size of the facilitation effect of patent protection on R&D, we used an ordered probit model for regression analysis (Cameron and Trivedi 2005; Long and Freese 2006). The specific model was designed as follows. Suppose that the R&D facilitation effect produced by patent protection depends on a series of factors captured in vector X. There is a potential policy-promoting effect, y^*, on the basis of each firm's characteristics. Suppose $y^* = X\beta + \varepsilon$, and ε follows the standard normal distribution. There are two critical values, a_1 and a_2, and $a_1 < a_2$. When y^* is less than or equal to a_1, y is equal to 1; when y^* is greater than a_1 and less than a_2, y is equal to 2; when y^* is greater than a_2, y is equal to 3. Specifically, we let Φ be the standard normal distribution function and we then have the following regression equations (Equations 11.1–3).

4 The survey in 2013 contained the key information needed for this study, such as a firm's response to stricter patent protection in terms of R&D expenditure, as well as information used for capturing the firm's patent motive, patent structure and protection approaches.

Equation 11.1

$$p(y = 1|X) = p(y^* \leq a_1|X) = \Phi(a_1 - X\beta)$$

Equation 11.2

$$p(y = 2|X) = p(a_1 < y^* \leq a_2|X) = \Phi(a2 - X\beta) - \Phi(a_1 - X\beta)$$

Equation 11.3

$$p(y = 3|X) = p(y^* > a_2|X) = 1 - \Phi(a_2 - X\beta)$$

Among these, y is the rank variable of the effect of patent protection on promoting R&D, and X includes the following:[5] the variables reflecting hypothesis 1, including the market motivation of the enterprise's patent maintenance behaviour and intensity of strategic patent use; two variables reflecting hypothesis 2, including the enterprise's number of patents and patent structure; and variables reflecting hypothesis 3—namely, the enterprise's choice for patent rights protection and confidence in the enforcement of patents protection. At the same time, combined with the data availability and drawing on the conclusions of previous research, in our regression we also controlled for some of the variables that reflect the qualifications of the enterprise, such as whether it was a government-recognised intellectual property enterprise, a high-tech enterprise, publicly listed or a centrally affiliated enterprise. Variables like the province of the enterprise's location and the industry to which it belonged are also controlled.

Empirical results

Descriptive statistics of the key variables

Table 11.1 shows the descriptive statistics attached to the main variables used in this analysis. Unless otherwise stated, the variables in the table are taken from the corresponding response data from relevant questions of the 2013 National Patent Survey. Variables not directly derived from the questionnaire or that need to be structured through a specific process included market-based patent maintenance motivation, intensity of strategic patent use, number of valid patents, proportion of invention patents, administrative protection of patent rights, judicial protection of patent rights and the level of confidence in patent law enforcement.

5 How these variables are constructed will be discussed in detail in section four.

Table 11.1 Descriptive statistics of the main variables (no. = 4,067)

Variable	Description	Mean	SD	Min. value	Max. value
Rdy	Degree of facilitation of patent protection on R&D (1–3)	2.48	0.61	1	3
dum_mark	Market-based patent maintenance	0.79	0.41	0	1
fss_r	Intensity of strategic patent use	0.56	0.25	0	1
Totpatg	No. of valid patents (1 = above median)	0.60	0.49	0	1
inv_sharg	Percentage of invention patents (1 = above median)	0.55	0.50	0	1
dum_adm_bh	Administrative patent protection	0.83	0.38	0	1
dum_law	Judicial patent protection	0.15	0.36	0	1
Xzbhxx	Confidence in patent law enforcement	0.31	0.46	0	1
Own	Ownership (1–3)	1.32	0.67	1	3
scale1	Size (1 = medium–large)	0.69	0.46	0	1
Zcqy	Intellectual property recognised (1 = yes)	0.34	0.47	0	1
Gxqy	High-tech (1 = yes)	0.70	0.46	0	1
Ssqy	Publicly listed (1 = yes)	0.13	0.33	0	1
Zyqy	Centrally owned (1 = yes)	0.07	0.25	0	1

Note: 1, 2 and 3 in the first variable, 'Rdy', refer, respectively, to: decreased R&D expenditure, no significant or clear impact on R&D expenditure and increased R&D expenditure. 1, 2 and 3 in the variable 'Own' refer, respectively, to domestic-owned enterprises, Hong Kong, Macau and Taiwan–owned enterprises, and foreign-invested enterprises.

We use the two variables capturing market-based motivation and the intensity of strategic patent use to characterise an enterprise's motivation for applying for or maintaining a patent. Among the two, the market-based motivation is defined based on the enterprise patent questionnaire in the National Patent Survey, for which the reasons enterprises could choose for maintaining their patents included 'to increase economic profits and reduce production costs', 'to use the patent as exchange for capital or as a bargaining chip' and 'to protect the enterprise's technology'. If an enterprise chose at least one of these options, they were defined in our study as exhibiting market-based patent maintenance behaviour and were labelled 1; otherwise, they were labelled 0. The intensity of the strategic use of patents in our study was defined according to the survey question about why the enterprise applies for its patent. In response to the information provided by an enterprise when applying for a patent, we count the number of non-traditional patent implementation motives[6] selected, except for those in the questionnaire who chose 'using patents to seize or expand the market' and 'to prevent imitation of enterprise technology

6 Non-traditional patent implementation motives include 'to meet government qualifications', 'to obtain grants and subsidies', 'to complete patent assessments', 'to enhance corporate social influence' and 'to block competitors'.

by others', which were considered the traditional patent implementation motives. We then divide the number of non-traditional motivations by the total number of options the enterprise chose to capture the intensity of strategic patent use.

The number of valid patents and the ratio of invention patents accounted for the two variables used to describe the characteristics of enterprise patents. Based on the name of the enterprise, the number of patents that are 'in force' for the enterprise as of the end of 2012 is calculated from the SIPO patents database; the variable 'Totpatg' is labelled 1 if the number of valid patents is above the sample median; otherwise, it is labelled 0. Similarly, based on the name of the enterprise, we obtained the number of invention patents that are 'in force' as of the end of 2012, calculated the proportion of invention patents in the total number of patents in force and defined enterprises above the median as 1, otherwise 0, thus constructing the 'inv_sharg' variable.

We used administrative patent rights protection, judicial patent rights protection and confidence in patent law enforcement to reflect the features of patent protection behaviour. For administrative patent rights protection, we use the response data for the following question: 'Through which means do you want to protect the patent rights of your enterprise?' Enterprises were limited to two responses from a list of choices.[7] Enterprises choosing 'report to the patent administration authority by calling 12330' or 'hope that the patent management authorities take the initiative to investigate and deal with the claimed violations' were defined as being inclined towards the administrative protection of patents and were labelled 1; otherwise, they were labelled 0. Similarly, the judicial patent rights protection variable was based on how enterprises answered the above question. If one of their two responses was 'go directly to court for litigation', they would be defined as being inclined towards using the judicial system to protect their patents and were labelled 1; otherwise, they were labelled 0. We constructed the confidence variable by including the responses to the question: 'What is the most striking impression of how administrative law enforcement resolves patent disputes in your enterprise?' Responses were limited to three choices and if one of those was 'administrative mediation can resolve disputes', those enterprises were defined as having confidence in administrative enforcement and were labelled 1; otherwise, they were labelled 0. The statistical results in Table 11.1 show that the variables fall within a reasonable range. Furthermore, we calculated the correlation coefficients for the main explanatory variables and found that the pairwise correlation coefficients between the variables were less than 0.3, suggesting that the subsequent regression was less adversely affected by multicollinearity.

7 The choices include 'report to the patent administration authority by calling 12330', 'hope that the patent management authorities take the initiative to investigate and deal with the claimed violations', 'settled through negotiation', 'go directly to court for litigation' and 'other'.

Distribution of the effect of patent protection on R&D expenditure

Table 11.2 shows the statistical distribution of the effect of patent protection on R&D expenditure. The results show that 52.5 per cent of enterprises believe that patent protection will enhance their own R&D expenditure, while 29 per cent believe that enhancing patent protection has no significant impact on their R&D expenditure. This suggests that other incentives—such as trade secrets and government subsidies other than factors of the patent system itself—also play a role (Wright 1983; Teece 1986; Gallini and Scotchmer 2002). The strategic patent application behaviour and the substitution system render the facilitative effect of patent protection on R&D relatively insignificant. At the same time, 11.9 per cent of enterprises believe that the effect of patent protection on R&D expenditure is unclear.[8]

Table 11.2 Distribution of the effect of patent protection intensity on R&D expenditure

Effect of patent protection on promoting R&D	Sample size	Proportion (%)
Patent protection increased R&D expenditure	4,484	52.46
No significant impact	2,478	28.99
Unclear	1,019	11.92
Patent protection decreased R&D expenditure	566	6.62

Source: Authors' calculation.

Structural differences in the effect of patent protection on promoting R&D

Column 1 in Table 11.3 examines the role of market-based motivation and intensity of strategic patent use on R&D promotion. The regression results show that enterprises with market motivation have more favourable evaluations of the effect of patent protection on R&D promotion than their counterparts. This relates to the fact that the patent behaviour of Chinese enterprises has been influenced by public targets and incentives. Enterprises that maintain patents to 'meet government qualifications', 'obtain grants and subsidies' or 'complete patent index assessments' are not as sensitive to patent protection as those that maintain patents to 'increase economic profits and reduce production costs' or 'protect the technology of the enterprise'. Since the enhancement of patent protection can significantly increase the patentability of a technology, the enterprises that follow marketisation principles

8 In our analysis, we classify 'no significant impact' and 'unclear' as one category, and define it as 'no significant impact'. The conclusion is robust even after removing the 'unclear' sample.

can more deeply actualise the important role of increasing patent protection with the goal of increasing the market value of their patents. Therefore, the incentive effect of patent protection on R&D is found to be more significant in such enterprises.

The empirical results also show that the stronger the strategic motivation of enterprises, the lower will be the enterprise's evaluation of the facilitative effect of patent protection on R&D. In other words, benchmark non-strategic motivations can enhance the effects of patent protection more than nascent strategic motivations. For example, enterprises that apply for patents for strategic use will be more likely to apply from a defensive stance, such as being influenced by propaganda, as opposed to those seeking to apply for patents for their industrial use. These patents are driven by a market strategy and do not carry any direct implementation characteristics. Although it helps enterprises secure a certain position in the market, the incentive effect on R&D is still limited.

Column 2 examines the moderate effect of the total number of patents, plus the ratio of invention patents in the total, on R&D promotion. The empirical results show that there is a significant positive correlation between the total number of patents and the facilitative effect of patent protection. The higher the number of patents accumulated by an enterprise, the more patents are applied to the patent portfolio and the greater will be the facilitative effect of patent protection on R&D promotion. At the same time, the proportion of invention patents is positively correlated with the effect of patent protection, but it is not statistically significant. These results show that the utility model still constitutes an important model of technological innovation within China's enterprises, and high-level inventions that incentivise greater R&D are concentrated in special industries and specific samples. They are not yet significantly reflected in the overall sample. For innovation to help upgrade China's industrial structure, there is a need to use multiple and different innovation models, while taking advantage of the roles of inventions, utility models and designs.

Column 3 examines the relationship between the choice of using either the administrative or the judicial system to protect patent rights and the enhancement of R&D. The regression results show that enterprises that choose the administrative protection system are more inclined to believe that intensified patent protection can promote their R&D expenditure than the enterprises that do not adopt the administrative system as their main line of defence. At the same time, compared with enterprises that do not use the judicial system as the main way to protect patent rights, these enterprises show greater incentive to increase R&D. Administrative protection and judicial protection are the two formal systems of patent protection in China that constitute an important institutional basis for enhancing the effect of patent protection on R&D promotion. Both increase the flexibility of choices available to the patent holder in the process of enforcing rights and both promote the development of patent protection, but on different dimensions. At the same

time, from the point of view of trusting law enforcement, enterprises that believe in the ability of administrative patent law enforcement to resolve patent disputes are more inclined to think that patent protection has a strong incentivising effect on R&D. The full potential of any facilitative effect of patent protection on R&D rests on the basis of confidence in administrative protection and flexibility on behalf of the patent holder or applicant.

Table 11.3 Analysis of structural differences in the effect of patent protection on promoting R&D

	(1)	(2)	(3)	(4)	(5)
Market-based patent maintenance	0.32***			0.28***	0.28***
	(0.04)			(0.04)	(0.05)
Intensity of strategic patent utilisation	–0.19**			–0.16**	–0.17**
	(0.08)			(0.08)	(0.09)
Total number of patents (1 = above median)		0.13***		0.12***	0.08*
		(0.04)		(0.04)	(0.05)
Invention patents (1 = above median)		0.03		0.02	–0.00
		(0.04)		(0.04)	(0.05)
Administrative protection			0.13***	0.12**	0.12**
			(0.05)	(0.05)	(0.05)
Judicial protection			0.08	0.07	0.12*
			(0.05)	(0.05)	(0.06)
Confidence in patent law enforcement			0.34***	0.30***	0.26***
			(0.05)	(0.05)	(0.05)
Hong Kong, Macau, Taiwan	0.19***	0.20***	0.20***	0.20***	0.23***
	(0.07)	(0.07)	(0.07)	(0.07)	(0.07)
Foreign	0.01	0.01	0.02	0.03	0.03
	(0.06)	(0.06)	(0.06)	(0.06)	(0.06)
Medium–large size	0.11**	0.09**	0.10**	0.07	0.09*
	(0.04)	(0.04)	(0.04)	(0.04)	(0.05)
Intellectual property recognised	0.07	0.08*	0.08*	0.04	0.08
	(0.04)	(0.04)	(0.04)	(0.05)	(0.05)
High-tech	0.08*	0.05	0.10**	0.08*	0.09*
	(0.05)	(0.05)	(0.05)	(0.05)	(0.05)
Publicly listed	–0.04	–0.04	–0.04	–0.07	–0.02
	(0.06)	(0.06)	(0.06)	(0.06)	(0.07)
Centrally affiliated	0.07	–0.02	0.04	0.07	0.08
	(0.07)	(0.08)	(0.08)	(0.08)	(0.08)
cut1_cons	–6.01***	–5.94***	–5.57***	–5.42***	–5.24***
	(0.24)	(0.32)	(0.15)	(0.27)	(0.27)

	(1)	(2)	(3)	(4)	(5)
cut2_cons	–4.56***	–4.50***	–4.12***	–3.95***	–4.01***
	(0.24)	(0.33)	(0.13)	(0.27)	(0.27)
Pseudo r2	0.03	0.02	0.03	0.04	0.04
Log likelihood	–3,520.53	–3,548.13	–3,435.15	–3,404.13	–2,962.72
No.	4,171	4,169	4,071	4,067	3,627

* $p < 0.1$ significance level

** $p < 0.05$ significance level

*** $p < 0.01$ significance level

Notes: An ordered probit model was used. All regressions control for provincial and industrial fixed effects. The base group of enterprise ownership are domestic-owned enterprises; the base group of size are small and micro-enterprises; the base group of intellectual property qualification are enterprises without intellectual property rights acknowledged by the government above the provincial level; the base group of high-tech enterprise qualification are non-high-tech enterprises; the base group of publicly listed enterprises are unlisted enterprises; the base group of centrally affiliated enterprises are non-centrally affiliated enterprises. Robust standard error shown within parentheses.

Source: Authors' estimations.

Column 4 discusses the moderate effect on promoting R&D of patent motives, the number and structure of patents and approaches to protection. Regression results show that these factors are robust in their correlation with the effect of patent protection on R&D. The corresponding economic explanation is the same as that discussed separately, so we will not repeat it here. Finally, given the questionnaire options of 'unclear' and 'no significant impact' were put into one category when constructing the patent protection R&D facilitation effect variable, 'unclear' could contain a lot of noise. Therefore, in column 5, the sample that answered 'unclear' was removed. The empirical results confirm that the basic conclusion is consistent with previous ones, showing that the conclusions for hypotheses 1–3 are robust.

It is worth mentioning that there are significant correlations between some factors in the control variables and effects on R&D promotion. In contrast, Hong Kong, Macau and Taiwan–owned enterprises, large and medium-sized enterprises and high-tech enterprises were more inclined to believe that increased patent protection would significantly enhance their R&D expenditure. Listed companies and centrally affiliated enterprises do not demonstrate stronger belief that patent protection will enhance R&D expenditure compared with non-listed companies and non-centrally affiliated enterprises. The economic explanation is that the competitive advantage of centrally affiliated enterprises is likely to come from trade and resource monopoly, rather than technological innovation, so the evaluation of the incentive effect of patent protection on R&D is limited. Meanwhile, listed enterprises cannot genuinely have technological innovation and corresponding R&D expenditure as prerequisites for the realisation of capital and operational growth, so the incentive effect of patent protection on R&D is also limited there.

Conclusion and policy suggestions

Using data from the 2013 National Patent Survey, this chapter reveals the impact of patent protection on R&D expenditure through the study of the survey question 'How does stricter patent protection affect R&D expenditure in your enterprise', and subsequently analysed the effect of patent protection on R&D facilitation. We then discussed the three main structural differences in how the relationship between patent protection and R&D expenditure is manifested in Chinese enterprises: as patent motives, the number and structure of patents and the selected method of patent rights protection. The main conclusions are as follows.

First, the implementation of national patent protection policies is found to be positively and significantly associated with enterprise expenditure on R&D. The survey data we examined identified some 52.5 per cent of enterprises believed that stricter patent protection would increase their R&D expenditure, whereas 29 per cent of enterprises believed that increased patent protection would have no significant impact on their R&D expenditure.

Second, the facilitative effect of patent protection on R&D differs structurally among the motives behind patent application, the number and structure of patents and the method of patent protection. Compared with traditional market motivations, strong patent protection does not have the effect of increasing R&D expenditure for administrative-driven and strategic-driven models. If the enterprise depends on market forces to apply patents then patent protection is conducive to maintaining strong incentives for R&D expenditure; on the other hand, if the enterprise applies the patent for administrative purposes, the incentive effect will be limited. At the same time, patent applications driven by strategic motives to some extent curb the facilitative effect of patent protection on R&D. This shows that if the purpose of applying for and maintaining a patent is to use the 'patent formation as exchange for capital' and 'to enhance corporate social influence', rather than 'to increase economic profits and reduce production costs', patent protection will greatly reduce any facilitative effects on R&D expenditure. Patent protection also increased the effect of R&D facilitation for enterprises that have accumulated a relatively high number of patents. Patent structure, which is represented by the ratio of invention patents in the total, did not play a significant role in promoting R&D expenditure. Compared with protecting patent rights through non-administrative channels, a decision to use the administrative protection of patent rights resulted in a higher evaluation of the facilitation effect of patent protection on R&D. Moreover, if enterprises have sufficient confidence in the administrative protection of patent rights, their evaluation of a positive effect of patent protection on R&D expenditure will also be higher.

In light of these results, we present the following three policy suggestions.

First, special attention should be given to the motivation behind patent applications. Patents are no longer a straightforward defensive method of protecting innovation, but are now also used as commercial tools. Strong patent protection here is not associated with increased R&D expenditure where the motivations for the patent are administrative and strategic, both of which reduce the innovation incentive effect of the patent system. Second, enterprises should strive to achieve balance between patent quantity and quality and to gradually establish a high-quality growth model. Currently, patent quantity and quality management revolve around the goal of 'quantity first then quality'. In general, R&D expenditure in the majority of Chinese enterprises remains limited, and the most common patent structure is the utility model. Also, there is a lack of will for continuous expenditure on R&D in companies with a favourable (high) invention patent structure. However, international experience suggests that upgrading a country's patent profile must rely on high-end inventions. A reasonable patent structure and the necessary R&D expenditure are the core elements of increasing corporate innovation capacity. Therefore, China needs to utilise multiple innovation models and the role of various types of patents, while establishing a more rational orientation for its national patent policy.

Finally, China's unique 'double-track' judicial and administrative patent rights enforcement and protection mechanism should be strengthened to enhance innovators' level of confidence in enforcement. We found that administrative protection and the ability of enterprises to successfully use administrative enforcement have a positive impact on subsequent R&D expenditure. Administrative enforcement is the consolidation and expansion of the private rights of intellectual property and constitutes a safeguard of these rights. Nonetheless, both judicial protection and administrative enforcement support China's innovation-driven development strategy. Therefore, the government needs to take advantage of the dual aspects of judicial protection and administrative enforcement to strengthen property rights.

References

Arundel, A. (1995), *Innovation strategies of Europe's largest industrial firms: Results of the survey for information sources, public research, protection of innovations and government programmes*, Final Report, MERIT Institute, University of Limburg.

Beneito, P. (2006), The innovative performance of in-house and contracted R&D in terms of patents and utility models, *Research Policy* 35(4): 502–17. doi.org/10.1016/j.respol.2006.01.007.

Blind, K., Edler, J., Frietsch, R. and Schmoch, U. (2006), Motives to patent: Empirical evidence from Germany, *Research Policy* 35(5): 655–72. doi.org/10.1016/j.respol.2006.03.002.

Boldrin, M. and Levine, D. K. (2008), *Against Intellectual Monopoly*, Cambridge: Cambridge University Press.

Burk, D. L. and Lemley, M. A. (2009), *The Patent Crisis and How the Courts Can Solve It*, Chicago: University of Chicago Press. doi.org/10.7208/chicago/9780226080635.001.0001.

Cameron, A. C. and Trivedi, P. K. (2005), *Micro-econometrics: Methods and applications*, New York: Cambridge University Press. doi.org/10.1017/CBO9780511811241.

Chen, Y. and Puttitanun, T. (2005), Intellectual property rights and innovation in developing countries, *Journal of Development Economics* 78(2): 474–93. doi.org/10.1016/j.jdeveco.2004.11.005.

Cohen, W. M. and Goto, A. N. (2002), R&D spillovers, patents and the incentives to innovate in Japan and the United States, *Research Policy* 31(8): 1349–67. doi.org/10.1016/S0048-7333(02)00068-9.

Gallini, N. and Scotchmer, S. (2002), Intellectual property: When is it the best incentive system? *Innovation Policy and the Economy*, 2: 51–77. doi.org/10.1086/653754.

Gilbert, R. (2011), A world without intellectual property? A review of Michele Boldrin and David Levine's 'Against Intellectual Monopoly', *Journal of Economic Literature* 49(2): 421–32. doi.org/10.1257/jel.49.2.421.

Ginarte, J. C. and Park, W. G. (1997), Determinants of patent rights: A cross-national study, *Research Policy* 26(3): 283–301. doi.org/10.1016/S0048-7333(97)00022-X.

Harabi, N. (1995), Appropriability of technical innovations: An empirical analysis, *Research Policy* 24(94): 981–92. doi.org/10.1016/0048-7333(94)00812-4.

Helpman, E. (1993), Innovation, imitation, and intellectual property rights, *Econometrica* 61(6): 1247–80. doi.org/10.2307/2951642.

Jaffe, A. B. and Lerner, J. (2006), *Innovation and its Discontents: How our broken patent system is endangering innovation and progress, and what to do about it*, Princeton, NJ: Princeton University Press.

Kanwar, S. and Evenson, R. (2009), On the strength of intellectual property protection that nations provide, *Journal of Development Economics* 90(90): 50–6. doi.org/10.1016/j.jdeveco.2008.11.006.

Kim, Y. K., Lee, K., Park, W. G. and Choo, K. (2012), Appropriate intellectual property protection and economic growth in countries at different levels of development, *Research Policy* 41(2): 358–75. doi.org/10.1016/j.respol.2011.09.003.

Klemperer, P. (1990), How broad should the scope of patent protection be? *RAND Journal of Economics* 21(1): 113–30. doi.org/10.2307/2555498.

Lin, J. (2003), Backward advantage or backward disadvantage: A discussion with Yang Xiaokai, [in Chinese], *China Economic Quarterly* 2(2): 989–1004.

Long, J. S. and Freese, J. (2006), *Regression Models for Categorical Dependent Variables Using Stata*, 2nd edn, College Station, Tex.: Stata Press.

Mansfield, E. (1986), Patents and innovation: An empirical study, *Management Science* 32(2): 173–81. doi.org/10.1287/mnsc.32.2.173.

Maskus, K. E. (2000), Intellectual property rights and economic development, *Case Western Reserve Journal of International Law* 32(3): 471–506.

Maskus, K. E. and McDaniel, C. (1999), Impacts of the Japanese patent system on productivity growth, *Japan & the World Economy* 11(4): 557–74.

Nordhaus, W. (1969), *Invention, Growth and Welfare: A theoretical treatment of technological change*, Cambridge, Mass.: MIT Press.

Shapiro, B. C. (2001), Navigating the patent thicket: Cross licenses, patent pools, and standard-setting, in A. B. Jaffe, J. Lerner and S. Stern (eds), *Innovation Policy and the Economy: Volume I*, pp. 119–50, Cambridge, Mass.: MIT Press. doi.org/10.2139/ssrn.273550.

Teece, D. (1986), Profiting from technological innovation: Implications for integration, collaboration, licensing and public policy, *Research Policy* 15: 285–94. doi.org/10.1016/0048-7333(86)90027-2.

Wright, B. D. (1983), The economics of invention incentives: Patents, prizes and research contracts, *American Economic Review* 73(4): 691–707.

Yang, G. and Maskus, K. E. (2001), Intellectual property rights, licensing, and innovation in an endogenous product-cycle model, *Journal of International Economics* 53(1): 169–87. doi.org/10.1016/S0022-1996(00)00062-3.

Yin, Z., Ye, J., Huang, Y. and Qin, X. (2013), Intellectual property protection and enterprise innovation: Mechanism and empirical test, [in Chinese], *World Economy* 12: 111–29.

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