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Intellectual property protection, technological innovation and enterprise value—An empirical study on panel data of 80 advanced manufacturing SMEs

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Abstract

Study the role of intellectual property protection in advanced manufacturing SMEs. Is it to protect the growth of advanced manufacturing SMEs, or to inhibit the growth of SMEs in advanced manufacturing? the paper brings the medium variable – technological innovation to explore acting paths of intellectual property protection in enterprises' value improvement. Through analysis of panel data of 80 SMEs of advanced manufacture collected during the period from 2013 to 2015, Research results show that as for SMEs of advanced manufacture, the inverted-U relationship still exists in the influences brought by intellectual property protection to enterprise values. Meanwhile, U-shaped relations exist between intellectual property protection and technological innovation. Increase of technological innovation investment can promote increase of enterprise values.

Keywords: Intellectual property; Enterprise values; Technological innovation

1. Introduction

SMEs play an important role in global innovation of advanced manufacture technologies. 80% of American technological innovation is sourced from SMEs. 65% of German SMEs have conducted R & D activities. Professional R & D departments are set in 40% of SMEs. Per capita innovation achievements in SMEs of the EU are twice those of large corporations. Promotion of innovation ability of SMEs and cultivation of hidden champion enterprises have become a key link to achieve transformation from "Chinese manufacture" to "Chinese creation". As for SMEs of advanced manufacture, intellectual properties play an important role as a core intangible asset as it can motivate enterprises to increase R & D investment and keep innovation advantages. Wu and Ning (2017) research

AbbreviationsSMEs, Small and Medium Enterprises; R&D, Research and Development; EU, European Union

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shows that intellectual property protection is conducive to the development of advanced manufacturing (Wu & Ning, 2017). However, Ma and Peng (2018) research shows that the public domain of intellectual property rights is facing the expansion of intellectual property rights and the erosion of public ownership (Ma & Peng, 2018). Academic circles focus on the relationship between intellectual property rights and technological innovation and enterprise value promotion. The academic circle researches intellectual property protection, enterprise values and technological values mainly in the following aspects. As believed by Patricia and Le Bas (2015), through technological innovation, an enterprise can reduce the production cost, strengthen the market competitiveness and enhance the probability. Based on empirical analysis results of medical and electronic industries (Patricia & Le Bas, 2015). Hirschey (2012) found significant positive correlation between the R & D investment, R & D intensity and the enterprise values (Hirschey, 2012). Relations between intellectual property protection and technological innovation. As believed by Li, Guo, and Zhang (2015) selected data of over 20,000 enterprises in 61 countries as the research object and found that enterprises' innovative investment can be motivated by intellectual property protection (Li et al., 2015). Through empirical research, Li, Gong, and Qi (2013) and Dang (2016) found the inverted-U relation between intellectual property protection and technological innovation (Dang, Liu, & Luo, 2016; Li et al., 2013). Wei, Yu, and Cai (2016) verified that the leverage effect brought by intellectual property protection to enterprises' technological innovation in 2012 was doubled in comparison with 2002 (Li, Yu, & Cai, 2016). Among domestic and foreign scholars' researches on the relations between intellectual property protection, technological innovation and enterprise values, there are overall analyses based on the whole industry as well as those targeted at a specific industry. However, there is no analysis aiming at the special target – SMEs of advanced manufacture. SMEs play an important role in China's national economy and social development and also play a significant role in supporting the innovation-driven strategies. Hence, the paper will take panel data of SMEs of advanced manufacture as the sample, introduce the medium variable – technological innovation based on their innovation-oriented mission and research acting paths of intellectual properties on enterprise values.

2. Methodology

2.1. Theories and hypotheses

(1) Index of intellectual property protection

The level of intellectual property protection is jointly decided by legislation level and law enforcement level of intellectual properties. Legislation of intellectual properties in China is conducted uniformly by the state. Legislation levels in different regions can be roughly deemed to be equivalent. Hence, the level of intellectual property protection in each region finally depends on the law enforcement intensity of intellectual properties. Due to non-synchronization in China's economic development and differences in regional culture, measurement of the index of intellectual property protection shall be denoted by the amended GP index. The index of intellectual property protection is denoted by multiplying the legislation index of intellectual properties by the law enforcement index of intellectual properties, namely $G(t) = L(t)*E(t)$, wherein L(t) denotes the legislation index of intellectual properties, which is expressed by the GP index of intellectual property protection. Since 2008, the GP index of intellectual property protection in China was kept at 4.857. E(t) was measured and computed with the intellectual property law-enforcement index mode proposed by Dang Guoying (2016):

$$E(t) = \frac{2}{3} \times \frac{ZL_{it}}{MAXZL_i} + \frac{1}{3} \times \frac{ZL_{it}}{MAXZL_t} \quad (1)$$

where: ZLit denotes the number of registered cases concerning patent disputes in different areas during different years; MAXZLi denotes the maximum number of registered cases concerning patent disputes in different areas during the same year; MAXZLt denotes the maximum number of registered cases concerning patent cases investigated in the same area during different years.

Hereby, intellectual property protection indexes of some regions in China during recent years are shown in Table 1.

(2) Intellectual Property Protection and Enterprise Values

With protection of intellectual properties, intellectual capitals such as talent technologies and trademarks of enterprises can be protected. In this way, enterprises can win the market monopoly advantages.

On this basis, the paper proposes the following hypotheses:

H1a: Significant positive correlation exists between proper intellectual property protection and enterprise value growth;
H1b: Significant negative correlation exists between excessive intellectual property protection and enterprise value growth.

(3) Intellectual Property Protection and Technological Innovation

As for relations between intellectual property protection and technological innovation, the theoretical circle holds two standpoints. As believed by most scholars, the intellectual property protection can obviously promote technological innovation; the intellectual property protection limits innovation investment to investors and motivates the tech-

Table 1
Intensity of Intellectual Property Protection in Chinese Areas from 2013 to 2015.

Year	2013	2014	2015	Year	2013	2014	2015
Beijing	1.178	1.649	1.706	Shandong	2.172	1.899	1.998
Hebei	0.694	1.599	1.826	Henan	2.862	1.909	1.885
Shanxi	0.308	1.659	0.429	Hubei	1.222	2.004	1.318
Inner Mongolia	1.671	0.816	1.628	Hunan	1.538	1.504	1.789
Liaoning	0.712	1.455	1.638	Guangdong	3.672	4.857	3.563
Jilin	0.880	1.708	1.281	Guangxi	0.307	0.894	1.631
Heilongjiang	0.806	0.597	1.344	Chongqing	1.088	1.200	3.136
Shanghai	1.312	2.717	2.893	Sichuan	1.701	1.385	2.986
Jiangsu	1.032	1.980	2.140	Guizhou	0.375	0.176	0.468
Zhejiang	2.243	0.863	4.857	Yunnan	0.644	0.958	1.671
Anhui	0.866	1.379	1.767	Shaanxi	1.756	1.624	1.705
Fujian	1.022	1.495	1.742	Gansu	0.686	1.344	1.657
Jiangxi	0.744	1.230	1.703				

Note: Basic data is sourced from Statistical Annual Report of Intellectual Property Office of the People's Republic of China, China Statistical Yearbook.

nological innovation. As believed by some scholars, intellectual properties are owned by the public, while the marginal cost is zero. If intellectual properties are valued, the marginal cost will increase, while technological innovation development will be hindered. Hence, the following hypotheses are proposed:

H2a: Significant positive correlation exists between proper intellectual property protection and technological innovation;
H2b: Significant negative correlation exists between excessive intellectual property protection and technological innovation.

(4) Technological Innovation and Enterprise Values

Technological innovation becomes an important motivation for growth of enterprise values. Research results indicates that significant correlation existed between Tobin's Q and R&D. High-tech enterprises which announce the increase of R&D expenditures play a role in increasing stock prices. Meanwhile, technological innovation can promote general increase, excessive increase and long-term increase of enterprises values, which is mainly embodied in increase of tangible asset values and increase of potential chance values. By increasing the investment in technological innovation, enterprises can increase the production efficiency as well as that of other enterprise elements, so that enterprise values can realize continuous growth. On this basis, the following hypothesis is proposed:

H3: Significant positive correlation exists between technological innovation and increase of enterprise values.

(5) Intermediation Role of Technological Innovation

Technological innovation not only plays an intermediation role between intellectual property protection and economic growth, but also acts as an intermediary agent between enterprise social responsibilities and increase of enterprise values. However, the intermediation role played between intellectual property protection and enterprise value increase is weak. H4: Technological innovation plays an intermediation role between intellectual property protection and enterprise values.

H4: Technological innovation plays an intermediation role between intellectual property protection and enterprise values.

2.2. Model design

(1) Data Source and Sample Selection

At present, there is no uniform statistical caliber of advanced manufacture in China, so the paper accords with classification of high-tech industries (manufacture industry) released by the National Bureau of Statistics, selected small and medium enterprise board listed companies from 2013 to 2015 as the initial research samples, eliminated enterprises with incomplete data and finally used the data in research of 80 SMEs of advanced manufacture. There were 240 observation values. The amended GP index was adopted as the intellectual property protection index. Technological innovation data is sourced from R & D investment data disclosed in enterprise financial reports. Other financial data is sourced from Sina Finance and Economy and Wind News Financial Database. The paper applies software EXCEL and Eviews6.0 for statistical analysis of data.

(2) Variable Instruction

According to abovementioned theoretical analysis and hypotheses, the paper takes Tobin's Q as the dependent variable; intellectual property protection index, square of the intellectual property protection index and technological innovation as the independent variables; and other influential factors as control variables. The following model is established based on above hypotheses so as to verify correctness of these hypotheses.

$$H1: Q_{i,t} = \alpha_{i,t} + \beta_1 IPP_{i,t} + \beta_3 SIZE_{i,t} + \beta_4 DEBT_{i,t} + \beta_5 LEVE_{i,t} + \beta_6 EPS_{i,t} + \beta_7 SIPPi,t + \varepsilon_{i,t} \quad (2)$$

Table 2
Definition of variables.

Name of Variable	Name of Variable	Symbol of Variable	Definition of Variable
Independent Variable	Intellectual Property Protection	IPP	Amended GP index
	Square of Intellectual Property Protection Index	SIPP	Square of amended GP index
	Technological Innovation	INNO	R & D expenditure/term-end gross assets
Dependent Variable	Enterprise Value	TOBIN-Q	(stock value + gross liability)/total assets
Control Variable	Enterprise Size	SIZE	Natural logarithm of term-end gross assets
	Debt-to-asset Ratio	DEBT	term-end liabilities/term-end gross assets
	Earnings Per Share	EPS	net profits/total amount of capital stocks
	Comprehensive Lever	LEVE	(Operation Revenue-Operation Expenditure)/gross amount of profits

$$H2: INNO_{i,t} = \alpha_{i,t} + \beta_1 IPP_{i,t} + \beta_3 SIZE_{i,t} + \beta_4 DEBT_{i,t} + \beta_5 LEVE_{i,t} + \beta_6 EPS_{i,t} + \beta_7 SIPPi, t + \varepsilon_{i,t} \quad (3)$$

$$H3: Q_{i,t} = \alpha_{i,t} + \beta_2 INNO_{i,t} + \beta_3 SIZE_{i,t} + \beta_4 DEBT_{i,t} + \beta_5 LEVE_{i,t} + \beta_6 EPS_{i,t} + \varepsilon_{i,t} \quad (4)$$

$$H4: Q_{i,t} = \alpha_{i,t} + \beta_1 IPP_{i,t} + \beta_2 INNO_{i,t} + \beta_3 SIZE_{i,t} + \beta_4 DEBT_{i,t} + \beta_5 LEVE_{i,t} + \beta_6 EPS_{i,t} + \beta_7 SIPPi, t + \varepsilon_{i,t} \quad (5)$$

where: Qi,t denotes the Tobin's Q value of enterprise i during the year t, which is expressed by the ratio of the sum of stock market value and gross enterprise liability to the total enterprise assets; αi,t denotes an intercept item; εi,t denotes the error value; variable definitions of other indexes are shown in Table 2.

3. Results and discussion

3.1. Descriptive statistics

Descriptive statistics is conducted to main variables, as shown in Table 3.

The maximum value of intellectual property protection index is 4.857; minimum value is 0.597; and standard deviation is 1.201. This result indicates that despite of the uniform legislation level in different areas of China, the law enforcement effects are still quite different. As for square item of the intellectual property protection index, the standard deviation is 7.022, which is quite different in different areas. The mean value of technological innovation of SMEs is 0.039, namely the proportion of R & D investment in total enterprise assets is 3.9% and the standard deviation is 0.049, indicating that R & D investment levels of SMEs are similar. As for Tobin's Q values, the maximum is 6.530 and the minimum is 0.005, indicating that values are different in different enterprises. This result reflects the imbalance in development of SMEs. As for control variables, the mean value of enterprise seize is 12.842 and the average debt-to-asset ratio is 21.5%, indicating that enterprise sizes are different and the liability level is low. As for earnings per share, the maximum value is 5.833 and the minimum value is −1.071, indicating huge differences between enterprises. As for the comprehensive lever variable, the maximum and the minimum are positive and negative, respectively. The difference is huge and the standard deviation is 5.153, indicating that the probabilities of different enterprises are quite different.

Table 3
Descriptive statistics.

Name of Variable	Maximum	Minimum	Mean	Standard Deviation
IPP	4.857	0.597	2.290	1.201
SIPP	23.590	0.356	6.679	7.022
INNO	0.228	0.008	0.039	0.034
TOBIN-Q	6.530	0.005	0.325	0.565
SIZE	12.842	7.373	10.882	1.082
DEBT	0.960	0.011	0.215	0.168
EPS	5.833	−1.071	0.422	0.628
LEVE	27.988	−45.113	2.265	5.153

3.2. Empirical result analysis

With the proportion of R & D investment in term-end assets as the measurement variable of technological innovation, acting paths of intellectual property protection on enterprise values of SMEs of advanced manufacture are investigated. Results are shown in Table 4. ADJ-R2 reflects degrees of fitting results. The value approaching 1 more reflects the better fitting results. D-W values are smaller than 2. Self-correlation does not exist between variables, indicating that the established model is rational.

(1) Research on relations between intellectual property protection and enterprise values

Regression results of Model 1 show that the regression coefficient of the intellectual property protection index shows significant positive correlation on the confidence level of 1%. Meanwhile, the square regression coefficient of the intellectual property protection index shows significant negative correlation on the confidence level of 1%. This result indicates that the inverted-U relationship exist

Table 4
Testing results of intermediate effects.

Name of Variable	Model 1	Model 2	Model 3	Model 4
IPP	0.142***	0.020***		0.104***
	(15.137)	(5.887)		(8.756)
SIPP	−0.024***	−0.003***		−0.018***
	(−14.141)	(−5.382)		(−8.440)
INNO			0.366***	0.239***
			(7.759)	(10.620)
SIZE	−0.007***	−0.001	0.005***	0.004***
	(−6.217)	(−0.909)	(11.043)	(3.772)
DEBT	0.912***	0.054***	0.964***	0.916***
	(52.825)	(9.664)	(79.062)	(50.873)
EPS	0.030***	0.001***	0.021***	0.029***
	(3.749)	(10.119)	(3.730)	(3.866)
LEVE	−0.002***	0.001***	−0.002**	−0.003***
	(−6.359)	(10.119)	(−2.486)	(−8.684)
ADJ-R2	0.937	0.584	0.965	0.939
D-W值	1.675	0.825	1.076	1.483

Note: value in the brackets is the T statistical value; ***, ** and * present significance under the significant levels of 1%, 5% and 10%.

between intellectual property protection and enterprise values. In other words, proper level of intellectual property protection can promote increase of values of SMEs of advanced manufacture, while the excessive level of intellectual property protection will restrain increase of enterprise values, namely H1a and H1b are verified. It is proved that intellectual properties belong to one of enterprise intangible assets, and proper protection of them can make enterprises acquire intellectual rental in the capital market by virtue of intellectual asset advantages. However, on the other side, excessive protection will weaken enterprises' competitive stress, form excessive dependence on existing intellectual achievement advantages and go against continuous innovation and value increase of enterprises.

(2) Research on relations between intellectual property protection and technological innovation

By model 2, the inverted-U relation between intellectual property protection and technological innovation is verified. Hence, the "hypothesis of optimum intellectual property protection" is verified. This result indicates that strengthening of intellectual property protection can promote enhancement of enterprise innovation ability, but excessive intellectual property protection will bring adverse influences to technological innovation. In other words, H2a and H2b are verified.

(3) Estimation results on relations between technological innovation and enterprise values

With model 3, effects of technological innovation on enterprise values are verified. On the confidence level of 1%, the regression coefficient of technological innovation shows significant positive correlation, indicating that enhancement of an enterprise's technological innovation level can increase enterprise values. In other words, H3 is verified. With technological innovation, an enterprise can obtain authentication of high-tech enterprises. In addition, with support of governmental financial subsidy, tax reduction and exemption and other measures in high-tech enterprises, they can obtain extra earnings, which will promote their continuous innovation.

(4) Testing results of intermediary role

In model 4, the regression coefficient of intellectual property protection level is significantly correlated on the confidence level of 1%. In model 4, the regression coefficient (0.104) of the intellectual property protection index is smaller than the corresponding regression index (0.142) in model 1. As well, the absolute value of the regression coefficient (−0.018) of the square item of intellectual property protection index in model 4 is smaller than the absolute value of the corresponding regression index (−0.024) in model 1. As for the fitting degree, the values of goodness of fit, those of model 4 and model 1 are 0.939 and 0.937, respectively. Hence, the explanation degree of model 4 is increased in comparison with model 1. This result indicates that the intellectual property protection can promote enterprise technological innovation so as to increase enterprise values. In other words, technological innovation plays an intermediary role in relations between intellectual property protection and enterprise values. Hypothesis 4 is verified.

4. Conclusion

Research results show that as for SMEs of advanced manufacture, the inverted-U relationship still exists in the influences brought by intellectual property protection to enterprise values. Meanwhile, U-shaped relations exist between intellectual property protection and technological innovation. Increase of technological innovation investment can promote increase of enterprise values. On one side, the intellectual property protection is insufficient. The innovation motivation of SMEs of advanced manufacture is insufficient; the core competitiveness of technologies is insufficient. Labor division of global value chain functions is limited in middle-end and low-end value links. On the other side, excessive intellectual property protection will restrain diffusion of industrial technologies and lead to repeated innovation investment of SMEs. For this reason, (1) Classified management is carried out to SMEs of advanced manufacture. They're divided into classes A, B and C according to owning degrees of advanced technologies. As for class A enterprises with core advanced technologies, the dedicated protection plans of intellectual properties are carried out; as for class B enterprises which have certain R & D ability and stay at the stage of simulation and tracking, the plan of intellectual property ability enhancement is carried out; as for class C enterprises with weak R & D consciousness and weak R & D ability, the plan of breaking through intellectual property ability is

implemented. (2) "Substitution of subsidies with rewards" is used to encourage endogenous innovation of enterprises. Only through enlargement of governmental innovation awards especially setting of special awards for R & D investment of new technologies and new products of enterprises, cost and risks of SMEs in new product innovation can be borne; enterprise earnings can be increased; innovation activity of SMEs can be motivated.

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Authors' contributions

Zhenyuan Liu is the main writer of this paper. He proposed the main idea, deduced Logical relationship betweenIntellectual Property Protection, Technological Innovation and Enterprise Value. Renyan Mu completed the simulation, and analyzed the result. Shuhua Hu introduced the GP index in The level of intellectual property protection. Li Wang collected relevant data of advanced manufacturing SMEs. Song Wang Wang Song has collected data on intellectual property law enforcement in all provinces. All authors read and approved the final manuscript.

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