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Research on the relationship between high-quality patent development and enterprise value from the perspective of TML

Shiqiang Sun[a] Wu Yang[b] Sen Yang[c] and Tengfei Gao[d]

[a] School of Economics and Management, North China Institute of Science and Technology, China
[b] School of Economics and Management, University of Science and Technology Beijing, China
[c] School of Civil and Commercial Law, Shandong University of political science and law, China
[d] School of Journalism & Communication, Peking University, China

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Abstract

Purpose –This study examines the link between premium patent creation and corporate value through a TML lens, seeking to illuminate the integration of tech innovation, market needs, and legal safeguards in fostering top-tier patents. This synergy is pivotal for boosting firms' market worth and competitive edge.
Design/Methodology/Approach – From the perspective of TML, based on the data of CSMAR and INNOJOY, the relationship between the high-quality development of patents and enterprise value was analyzed by using the subjective and objective weighting method. The OLS two-stage regression model and the seemingly uncorrelated model SUR test were both adopted. The degree of state-owned holding is introduced between the two to test its moderating effect.
Findings – (1) High-quality patent development closely ties to enterprise value, reflecting tech innovation. Technical aspects show a stronger boost than market or legal qualities.(2) Greater state ownership enhances market and legal quality impacts on value, meaning higher state hold amplifies these qualities' value enhancement.(3) Patent quality dimensions vary in their impact across industries, all supporting "innovation-driven development" principles.

Keywords: TML vision, high-quality development of patents, enterprise value, state-owned holding degree, SUR test
JEL Classifications: O31,O34,038,G30,G32

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[a] School of Economics and Management, North China Institute of Science and Technology, Lecturer, First Author, E-mail: sun9330@126.com
[b] School of Economics and Management, University of Science and Technology Beijing, Professor, Corresponding Author, E-mail: fengqi2018buu@126.com
[c] School of Civil and Commercial Law, Shandong University of political science and law, Lecturer, Second author, E-mail: ys_ustb@163.com
[d] School of Journalism & Communication, Peking University, Lecturer, Third author, E-mail:teng_fei_gao@163.com

I. Introduction

Under the current pattern of poor competition, the patent technology innovation led by enterprise value is shifting from quantitative scale to qualitative efficiency (Zhu, Chen, & Wang, 2020; Chen, Lin, & Zhang, 2020; He, Cai, & Tao, 2021), how to promote the patent high-quality development and enhance enterprise value has become a key issue of concern for the government, industry, academia and research community. WIPO report shows that in 2020, China's PCT patent applications amounted to 68,720, surpassing the United States of America's 59,230 in the same period, ranking the world's first. The WIPO report shows that China's PCT patent applications will reach 68,720 by 2020, surpassing those of the United States (59,230 during the same period) and ranking first in the world. However, the Global Innovation Index 2020 (GII report) released by WIPO shows that China's innovation index is only ranked 14th in the world, and there is still a big gap with the developed countries represented by the United States, indicating that although China's patents occupy the advantage in quantity, its overall quality is low (Huang, Lao, & Mcphee, 2020), due to three reasons: firstly, technological risk. Patented technology has not formed a more comprehensive technology layout, and there are practical limitations of transformation and application in certain core technology areas. For example, the EUV incident of high-end lithography in 2019 and the list of "necklace technology" in 2020 show that China is still waiting for a breakthrough in the field of core technology; Second, market risk. Enterprises in the face of international market competition, the patent layout system is not perfect, coupled with the low level of patent quality, it is difficult to enter the international market for patented technologies, which is difficult to face the multinational organization of patent litigation and technical barriers and other issues; Third, the legal risk. Policy incentives and the uncertainty of patent rights, prompting many enterprises to focus on patent "quantity" rather than "quality", resulting in "patent bubble" and "innovation illusion" abound. This has led to the emergence of "patent bubble" and "innovation illusion", which has seriously hindered the value of enterprises.

As a knowledge carrier integrating technology, market and law and other related information, patent, by virtue of its creativity, value and exclusivity, not only helps enterprises to build technical barriers, legally and effectively exclude competitors from technical barriers, but also develops domestic and international markets, explores profit growth points and enhances enterprise value (Andrews, 2021). Existing research on the development of patent quality and enterprise value of the literature, the research perspective is relatively single, in the technical perspective on the forward citation and backward citation and other indicators (Cheng, 2021; Zhao, & Li, 2020), in the market perspective on the number of homologous families and the layout of the number of countries (Yang, Sun, & Chen, 2021; Li, Chu, & Wang, 2019), in the legal perspective on the number of claims and the duration of the patent (Qiang, Xiao,& Hang, 2020; Song, Chang, &Lin, 2021), and did not give full consideration to the coupling relationship between the three. Based on this, this paper decouples patent high-quality development into technical quality, market quality and legal quality under the TML perspective, and utilizes CSMAR and INNOJOY databases, adopts the subjective and objective assignment method, OLS estimation method and SUR test to explore the relationship between the three dimensions of patent high-quality development (technological quality, market quality and legal quality) and enterprise value, and verifies that It also verifies the moderating effect of the degree of state-owned holding, thus providing suggestions for cultivating high-value patents and realizing the goal of "Patent Power".

II. Research Basis and Assumptions

2.1 Techno-market-legal theory development

"Innovation" comes from the interpretation of economic growth, "scientific and technological progress, capital accumulation and the division of labor are the three elements of economic growth" (Smith, 1999). Later, Schumpeter (2006), in Economic Development Theory, combines innovation and economic development, pointing out that economic growth has dynamic changes with technological innovation (Schumpeter, 2006). As a result, this paper further refines the Technology-Market-Law Theory (i.e., TML Theory) by analyzing the integration process of technology, market, and law in technological innovation. In the first stage, Schumpeter (1962), in Capitalism, socialism and democracy, pointed out that R&D-based technological innovation disturbs the existing economic equilibrium, thus enabling technological innovators to obtain excess market profits (Schumpeter, 1962).Rosenbloom and Abernathy (1982) introduced the market elements into technological innovation, arguing that market elements are as important as technological elements (Rosenbloom, & Abernathy, 1982).The S-curve theory proposed by Foster (1986) also reconfirms that technological progress varies over time in the process of technological innovation (Foster, 1986). Core technology has economic value only after commercialized operation. The new growth theory believes that enterprises will actively carry out R&D activities and acquire core patents and knowledge in order to obtain monopoly market profits. The new growth theory believes that market expansion is not the result of exogenous factors, but is caused by the endogenous variables of technological innovation of enterprises in the system. Romer (1986) pointed out in "Increasing Returns and Long-Run Growth" that technology is endogenous and controllable (Romer, 1986), and regarded knowledge as the production factor that enables market expansion in the long run. Factor is seen as the driving force that allows markets to expand over time. However, due to the non-equilibrium nature of the market, new technologies are constantly emerging, resulting in the continuous technological innovation driven by the pursuit of excess market profits, which realizes the coupled development of technology-market. Although the new economic growth theory internalizes technological innovation and points out the important role of technological progress and knowledge accumulation in market expansion, it ignores the role of institutional factors, and it is difficult to analyze the institutional reasons for technological innovation and market expansion in a more comprehensive way. In the second stage, institutional economists define institutions as the moral norms of rules and behaviors, whose purpose is to constrain the personal behavior of individuals in the pursuit of utility maximization benefits (North, 1990). Institutions as the logical starting point for obtaining excess profits after technology is applied to the market, with the function of efficiently allocating technology and market resources. As an endogenous variable of technological innovation and market expansion, the system is introduced into the field of intellectual property jurisprudence, combined with the theory of technological innovation and economic development theory, and initially formed the jurisprudential economics of technological innovation. In the third stage, Japan, through the investigation of technological innovation projects, found that the proportion of technological elements in the whole innovation project is 38.82%, in the first place, the market element is second, 38.25%, the legal element accounts for 18.87%, and the sum of the remaining elements accounted for less than 5% (Saito, 1990), the results of this investigation unveiled the third convergence of the development of technological innovation theory. In addition, the information involved in the process of technological innovation and market expansion cannot be ignored, and the information in the whole process is attributed to the third element (Daghfous, & White, 1994). However, information itself does not

have independent characteristics, and its inclusion in the field of intellectual property jurisprudence can better explain the logical relationship between technological innovation and market expansion. Patented technology is easy to be imitated by technology pursuers because of its value and scarcity, and the legal system of intellectual property rights can effectively protect the legitimate rights and interests of patent technology owners. Technological innovation is the basic condition for market expansion. In the process of commercialization of core technology, the degree of technological innovation is constrained by legal factors, and core technology can only show its market value when it is operated commercially in the market under the perfect legal protection system of intellectual property rights.

2.2 Research hypotheses

2.2.1 Patent quality development and enterprise value

Under the perspective of TML, according to the competitiveness, value and exclusivity of patent high-quality development, it is decoupled into technical quality, market quality and legal quality. In terms of technical quality, the technical dimension, as the core element of patent high-quality development (Andrews, 2021), enhances the enterprise value mainly in two aspects: first, the degree of mastery of existing core technology, i.e., the correct use of the existing core technology; second, based on the existing core technology, the feasibility of the future development trend of the technology, i.e., to improve and develop the existing core technology, and to realize the whole industry chain design of the technology from the bottom to the top. Industry chain design. If the backward citation of an enterprise's patented technology is larger, it indicates that the technology has a big breakthrough in the technical basis of the field, which indicates that the patented technology is a leading technology, which can significantly enhance the market competitiveness of the enterprise (Mao, Johnston, & Yin, 2019), and the higher the value of the patent. In addition, if a patent has more forward citations, the greater the frequency of high citations, indicating that the technology is more easily accepted by multiple subjects in the market (Soonwoo, Jihong, & Sokbae, 2017), with a greater breadth of application, the better the performance of enterprise value. In terms of market quality, the U.S., Japan and Europe as the leading international patent certification than the national patent certification is more difficult, its patent examination system and protection system is more perfect, if the patent owner can obtain the U.S., Japan and Europe patent authorization of the three parties, it shows that the quality of this patented technology itself is higher (Kang, & Liu, 2020), and can be in the international market to form the scale of the patent family, which can help enterprises better open up and expand the international market, so as to get the best value of the enterprise. And expand the international market, so as to obtain excessive profits. In addition, if a certain patented technology can be cited by enterprises in many countries in the world, it also indicates the inventive value or common value of the patent (Li, Wang, & Wu, 2021), which helps the proliferation of technology in this field. In terms of legal quality, after a patent technology is authorized, it is very easy to be imitated or even copied by competitors. Such difficulties can be effectively solved by introducing the intellectual property protection system into the legal quality of patent technology (Meng, Lei, & Jiao, 2021; Liua & Lib, 2024). Based on the patent infringement model, the legal quality of patents is constructed from the number of claims and patent maintenance time. The number of claims refers to the number of items of a patent technical requirements to obtain legal protection, when the number of claims of a patent is larger, it means that the technical program of the patent is more complex, and the level of its technical creativity is higher (Harhoff, & Dietmar, 2016), which also reflects its higher value. Patent

maintenance time refers to the legal period stipulated in the Patent Law to ensure that the patent owner to obtain innovation revenue, in this period, the patent owner with the technology to monopolize the market, and through the transfer of the right to use and other ways to obtain a high amount of patent revenue, to enhance the value of the enterprise. Based on the above analysis, this paper puts forward the following hypotheses:

Hypothesis 1: Patent quality development can significantly increase enterprise value

Hypothesis 1a: Technology quality can significantly improve enterprise value

Hypothesis 1b: Market quality can significantly increase enterprise value

Hypothesis 1c: Legal quality can significantly improve enterprise value

2.2.2 Regulating effect of the degree of state ownership

Although the promotion of high-quality development of patents can effectively enhance the value of enterprises, this process has a long research and development cycle, large resource investment and high risk of failure and other uncertain factors, and it is difficult to give full play to its competitive advantages in the current competitive pattern of poor order and homogenization. Based on this, this paper argues that the degree of state ownership (i.e., the state's ownership and control of enterprise capital) can enhance the promotion effect of patent quality development on enterprise value, which is mainly manifested in three aspects: first, in terms of technology quality, patent R&D is a high-risk, large investment and long cycle of innovation activities. Therefore, enterprises with a high degree of state-owned holding can obtain relevant financial subsidies, bank loans and other financial and policy support through close contact with the government, which alleviates the financing constraints to a certain extent, and can accelerate the breakthrough of core patents and key technologies by increasing R&D investment (Dong, & Fang, 2019), realizing the efficient transformation of patent achievements (Burak, & Dindarolu, 2018), and applying the technological innovation activities effectively to improve enterprise value. EUV lithography, for example, foreign economies in China to implement the "technology lock" strategy, resulting in China and foreign developed economies, compared to the field of high-end chips lagging behind at least 1-2 generations of technology gap (at present, China's introduction of photolithography to 28nm-based, but foreign economies to 7nm is the main, and is even extending the 5nm and 3nm technology field). Therefore, in addition to solving the problem of "neck" technology, enterprises with a high degree of state-owned holding should focus on breaking through core technology, which can accelerate the construction of patent-intensive industries in the current technological field of the commanding heights, and through the optimization of the industrial layout, the construction of the whole industry chain from low-end to high-end, the formation of a high quality level of uniqueness of patents; secondly, in the market, the patent-intensive industry can be used to develop a high quality of patents. of patents; secondly, in terms of market quality, the market dimension is the commercialization goal of high-quality development of patents, mainly in the form of expanding the scope of the international market of patents, forming industrial alliances and cooperative research and development with other organizations, and so on, so as to obtain stable remuneration. Due to the uncertainty of the market, there may even be market failure. Higher degree of state-controlled enterprises because of its commercial and public welfare dual nature, in the face of foreign "technology lock", should undertake the national mission, the maintenance of national security should be the main focus, through the depth of the new market demand, upgrade and transformation of their own technology products and industry chain structure (Chen, Meng, & Lu, 2018), can improve the adaptive resilience of enterprises and the ability of sustainable development. In addition, in the international

market competition, enterprises can improve the efficiency of market resource allocation by opening up new technology fields, promote the establishment and operation of fair and just international market rules, and improve the market quality of patents; Third, in terms of legal quality, the legal dimension is the fundamental guarantee for the improvement of high-quality development of patents, which is mainly based on the property right relationship of patents (independent property right, dependent property right, and property right). Thirdly, in terms of legal quality, the legal dimension is the fundamental guarantee for the improvement of patent quality development, which is mainly protected in terms of the property right relationship of patents (independent property right, subordinate property right and cross-property right) and the legal protection period (the legal period stipulated for the protection of the inventor's innovation benefit). Core patents must be titled to form a technological monopoly (Cai, Chen, & Huan, 2019), and a sound intellectual property protection system can effectively protect the legitimate rights and interests of patent owners (Turchyn, & Jennifer, 2016). For enterprises with a high degree of state holding, by deepening the reform of the intellectual property protection system, the technical property rights relationship between different innovation subjects can be clarified, and further promote the competing behaviors of locking and locking between the core patent owner and the subsequent owner due to the formation of different property rights relationship (Mao, Chen, & Yin, 2019), which strengthens the legal quality of the patents to a certain extent.

Hypothesis 2: In the process of innovation development, the degree of state-owned controlling positively moderates the impact of patent high-quality development on enterprise value

Hypothesis 2a: the degree of state-owned controlling positively regulates the impact of technology quality on enterprise value

Hypothesis 2b: The degree of state ownership positively regulates the impact of market quality on enterprise value.

Hypothesis 2c: The degree of state ownership positively moderates the effect of legal quality on firm value.

III. Research Design

3.1 Data Source and Sample Distribution

The data of this paper comes from two databases, the first one is Cathay Pacific Database (CSMAR), through which the listed companies with market capitalization of over 10 billion dollars in GEM were searched on May 10, 2021, and the financial data of the above companies, such as the total assets, net assets, return on assets, and total profits, as well as the types of company ownership, were manually sorted out. The second one is INNOJOY Patent Search and Analysis System. On May 20, 2021, we searched the above listed companies' patent authorization information and patent citation information through this database. Since there is a time lag effect from application to authorization and citation (it takes 18 months for patent examination), i.e., the closer to the patent search date, the lower the number of authorized patents and citation frequency, in order to accurately obtain the patent data of the sample enterprises, based on the idea of "thick and thin," the study first manually searches all the patent data of individual enterprises applied for during the period of 2009 to 2019, and then manually searches all the patents applied for during the period of 2019. In order to accurately obtain the patent data of the sample enterprises, based on the idea of "thick and thin", this study first manually searches all the patent data applied by a single enterprise between 2009 and 2019, and then summarizes all the sample

enterprises to obtain the patent data of the whole sample. By comparing and analyzing the two data, excluding the abnormalities of the main financial indicators, ST companies and non-manufacturing companies finally compiled the financial data of 134 listed companies and the unbalanced data of 71,516 patents corresponding to them.

3.2 Definition of variables

(1) Explained variable: enterprise value. Tobin'Q is the market's expectation of the long-term trend of enterprise value, and this study adopts Tobin'Q as a proxy variable for enterprise value. Based on Zhao Zhongtao & Li Changying (2020) and Sui Jing, Jiang Cuiwen & Xu Qifa (2016) , so that the total assets of the company = the replacement cost of assets, the total assets are based on the total book value of the balance sheet, the market value = the total number of shares in issue * the enterprise's share price + long-term liabilities + current liabilities, and the enterprise's share price is based on the closing price of the same day at the time of data collection, then Tobin 'Q = (total number of shares issued * enterprise share price + long-term liabilities + current liabilities) / total assets of the company.

(2) Explanatory variable: patent high quality development. Currently, the measurement indexes about patent high-quality development mainly range from the number of citations, knowledge breadth, and patent maintenance time. However, this study believes that patent high-quality development has complexity and dynamics, and it is difficult to accurately respond to the comprehensive situation of patent high-quality development by relying on a single indicator only. Therefore, based on the TML perspective, this study decouples patent high quality development into technical quality Tech, market quality Mark and legal quality Law, and based on the INNOJOY patent library, selects the indicator system in each dimension, and synthesizes the patent high quality development by adopting objective and subjective assignment methods.

Table 1. Results of indicator empowerment

Primary Indicators	Secondary Indicators	Tertiary Indicators
High-quality development of patents	Technical quality（Tech）（0.3）	Number of highly cited patents（0.021）
		Forward citations（0.268）
		Backward citations（0.044）
	Market Quality（Mark）（0.4）	Number of homologous families（0.206）
		Number of Layout Countries（0.127）
	Legal quality（Law）（0.3）	Number of claims（0.146）
		Maintenance time（0.187）

(3) Moderating variable: degree of state-owned holding Gov. Based on the Cathay Pacific database (CSMAR), based on the share of corporate capital, it is classified into wholly state-owned (100%), absolute holding (more than 50%), and relative holding (less than 50% and is the largest holding shareholder), the sample companies are labeled as controlling shareholders, and the controlling status of controversial companies is checked and modified through the annual reports of the companies or the search engine. or search engine to check and modify. Dummy variables are set for the degree of state-owned holding, and the degree of controlling is from 1

to 3, where 3 indicates the highest degree of controlling.

(4) Control variables: based on the existing literature on enterprise value, this paper also controls the following variables. Return on Assets Roa, Operating LifeYear, and Price to Net Ratio Pbr. Total Assets = (Beginning Assets + Ending Assets)/2. Return on Assets Roa = Net Profit/Average Total Assets*100%. Years in business = Sample retrieval time - Business inception time in years. Price to Net Worth Ratio Pbr=Price per share/Net Assets per share. In order to eliminate the effect of differences in different measures, this paper standardizes the above variables with 5% shrinkage.

IV. Empirical analysis

4.1 Descriptive statistics and correlation coefficients

Table 2 shows the descriptive statistics and correlation coefficients of the variables, in which the standard deviations of Tobin'Q, Pro, Roa, and Year are large, reflecting the large gap between the operating conditions and profitability of the firms, which is then reflected in the market capitalization of the firms. The correlation coefficients of Tech, Mark, and Law with Tobin'Q are 0.408, 0.319, and 0.334, respectively, at the 1% threshold, indicating that all three can contribute to the value of firms. 'Q. The correlation coefficients are 0.408, 0.319, and 0.334, respectively, at the 1% threshold, indicating that all three contribute to firm value. However, the correlation coefficient between Gov and Tobin'Q is -0.275 at the 1% threshold, indicating that Gov has a negative effect on firm value. The rest of the variables are somewhat related to each other, but the correlation degree is not high, which has a noise reduction effect on the subsequent regression analysis. The correlation coefficients of the variables are less than 0.7, which initially proves that there is no serious problem of multicollinearity.

Table 2. Descriptive statistics and correlation analysis of variables

	1	2	3	4	5	6	7	8	9
Tobin'Q									
Tech	0.408***								
Mark	0.319***	0.467**							
Law	0.334***	0.172**	0.088						
Gov	-0.275***	-0.068	0.004	0.032					
lnA	0.046	0.073	0.153*	-0.023	-0.044				
Pro	-0.025	-0.033	0.067	0.134	0.014	-0.037			
Roa	0.147*	0.046	0.001	0.108	0.098	-0.041	0.434***		
Year	0.097	0.064	0.047	0.132	0.002	-0.122	-0.060	-0.110	
Mean	8.693	0.037	0.796	1.439	0.090	23.600	2.328	2.804	19.045
Sd	6.632	0.133	0.239	0.470	0.287	0.290	5.586	4.382	5.529
Min	1.070	0.000	0.000	0.000	0.000	23.560	-6.000	-1.150	9.000
Max	36.490	1.000	1.872	4.686	1.000	25.910	50.000	41.420	44.000

4.2 OLS two-stage model regression analysis

Analyzed by Stata15.0 software, Table 3 shows the regression results obtained by sequential regression based on the above model, in which Model 1 is the regression results of control variables on Tobin'Q, in which the regression coefficient of Roa on Tobin'Q is significantly positive (β=0.316, $p<0.05$), which This indicates that the return on assets of the firm has a positive contribution to the value of the firm. Roa refers to the efficiency of the use of the firm's own capital, which reflects the level of return on shareholders' equity of the firm, indicating that the sample firms get a higher return on income through investment. Model 2 shows the regression results of the three dimensions of high-quality development of patents (i.e., Tech, Mark, and Law) on Tobin 'Q. The regression result of Tech on Tobin'Q is the strongest, and the regression coefficient is significantly positive (β=13.181, $p<0.01$).Mark is the second strongest, and the regression coefficient is significantly positive (β=4.909, $p<0.05$).Law is the weakest, and the regression coefficient is significantly positive (β=4.909, $p<0.05$). The regression coefficient is significantly positive (β=4.909, $p<0.05$). Its regression coefficient is significantly positive (β=3.756, $p<0.01$).Model 3 is based on Model 2 with the addition of the moderating variable Gov. The results show that after the addition of Gov, the facilitating effect of Tech on Tobin's Q is weakened, decreasing from 13.181 to 11.645, whereas the facilitating effect of Mark and Law on The regression coefficients of Tobin'Q both increase, with Mark increasing from the previous 4.909 to 5.383, and Law increasing from the previous 3.756 to 3.905, indicating that the presence of Gov, although weakening the role of the technology dimension to a certain extent, improves the roles of the market dimension and the law dimension.

Model 3 shows the regression results of the moderating effect, where the coefficient of the interaction term between Gov and Tech is no longer significantly positive (β=-27.727, $p>0.1$), indicating that Gov does not positively moderates the relationship of Tech's positive influence on Tobin'Q. In addition, the coefficient of the interaction term between Gov and Mark in Model 4 is significantly positive (β=6.285, $p<0.1$), indicating that Gov positively moderates the relationship of Mark's positive influence on Tobin'Q. The coefficient of the interaction term between Gov and Law is significantly positive (β=7.433, $p<0.1$), which also indicates that Gov positively moderates the relationship of Law's positive influence relationship on Tobin's Q. Based on the simple slope test, the moderating effects of Gov*Mark and Gov*Law are plotted, and it can be seen from Figure 1 that in the context of higher Gov, the positive influence of Mark on Tobin'Q is significantly higher than that of lower Gov, indicating that Gov enhances Mark's Tobin'Q facilitating effect. Similarly, Figure 2 shows the effect of the interaction term between Gov and Law on Tobin'Q. It can be seen that in the context of higher Gov, the positive effect of Law on Tobin'Q is significantly higher than the scenario of lower Gov, indicating that Gov enhances the promotion effect of Law on Tobin 'Q's facilitating effect, thus, hypotheses 5 and 6 are again supported. In addition, the VIF values of the models are greater than 1 and less than 5, indicating that the multicollinearity in this study is within reasonable limits.

Table 3. OLS two-stage model regression results

	Model 1	Model 2	Model 3	Model 4
Control variable				
lnA	1.485 (0.75)	0.304 (0.17)	0.040 (0.02)	0.415 (0.26)
Pro	-0.126 (-1.12)	-0.160 (-1.59)	-0.177* (-1.86)	-0.172 (-1.84)
Roa	0.316** (2.18)	0.258** (2.01)	0.310** (2.54)	0.451 (3.09)
Year	0.146 (1.39)	0.059 (0.63)	0.061 (0.69)	0.063 (0.72)
Explanatory variables				
Tech		13.181*** (3.03)	11.645*** (2.82)	7.271* (1.69)
Mark		4.909** (2.05)	5.383** (2.37)	4.657** (2.09)
Law		3.756** (3.42)	3.905*** (3.75)	2.962** (2.49)
Moderating variables				
Gov			-6.628*** (-3.98)	-21.362*** (-3.85)
Interaction term				
Gov*Tech				-27.727 (-0.20)
Gov*Mark				6.285* (1.68)
Gov*Law				7.433* (1.81)
R^2	0.048	0.287	0.367	0.414
Adj-R^2	0.019	0.247	0.327	0.361
F-value	1.630***	7.240***	9.060***	7.82***
VIF	1.13	1.19	1.18	3.79

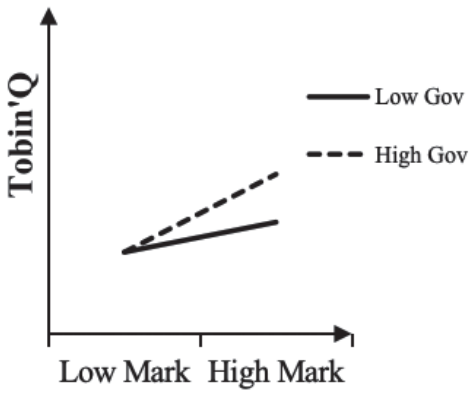

Figure 1. Gov, Mark & Tobin'Q

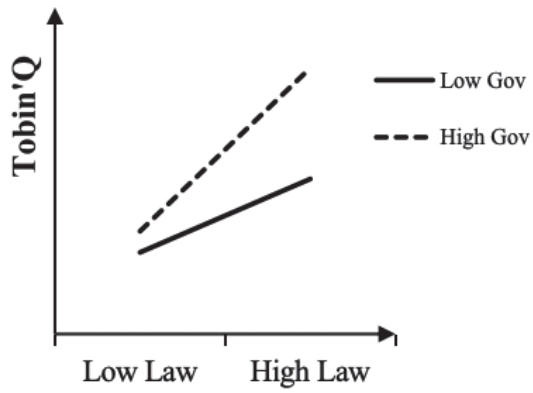

Figure 2. Gov, Law & Tobin'Q

4.3 Based on the seemingly uncorrelated model SUR test

In order to further explore whether there are industry differences in enterprise value due to patent quality development, based on the research of Yuan, Hou and Cai (2020), this paper divides the sample enterprises into four groups: materials and chemicals, biomedicine, information technology and machinery manufacturing. Through the seemingly uncorrelated model SUR test, it is found that there are industry differences in the impact of different dimensions of high-quality development of patents on enterprise value, as shown in Table 4. In the materials and chemicals industry, technology quality has a significant negative impact on enterprise value ($\beta1$=-14.469, $p<0.1$), indicating that such industries, although investing more in patent costs, but there is no obvious patent output, more in the form of "bubble patent" output, which has an impediment to the enhancement of enterprise value. Market quality has a significant positive effect on enterprise value ($\beta2$=7.093, $p<0.05$), and legal quality has a significant negative effect on enterprise value ($\beta3$=-4.550, $p<0.1$). In the biomedical industry, market quality has a significant positive effect on firm value ($\beta4$=16.096, $p<0.01$), legal quality has a significant positive effect on firm value ($\beta5$=5.681, $p<0.01$), and technological quality has no significant effect on firm value. In the information technology industry, technical quality has a significant positive effect on firm value ($\beta6$=66.786, $p<0.05$), while both market quality and legal quality have no significant effect on firm value. In the machinery manufacturing industry, technical quality has a significant negative effect on firm value ($\beta7$=-19.344, $p<0.05$), while both market quality and legal quality have no significant effect on firm value.

Table 4. Results of SUR test based on the seemingly uncorrelated model

Var	materials and chemicals	biomedicine	information technology	machinery manufacturing
Explanatory variables				
Tec	-14.469* (-1.79)	1.966 (0.35)	66.786** (2.01)	-19.344*** (-3.33)
Mark	7.093** (2.15)	16.096*** (3.34)	1.495 (0.43)	4.514 (1.56)
Law	-4.550* (-1.66)	5.681*** (4.51)	0.944 (0.38)	1.709 (1.28)
Control variable				
year	-0.014 (-0.12)	-0.054 (-0.31)	0.041 (0.22)	-0.145 (-1.35)
roa	1.004*** (3.08)	-0.042 (-0.32)	0.795 (1.42)	0.645*** (5.34)
pro	0.025 (0.11)	-0.291** (-4.49)	0.040 (0.13)	0.292** (2.02)
lna	--	10.335*** (5.15)	-0.802 (-1.32)	3.584*** (7.18)
R^2	0.363	0.483	0.290	0.433
Adj-R^2	0.189	0.354	0.041	0.313
F-value	2.09*	3.73***	1.17	3.60***
VIF	1.41	1.38	1.47	1.29

4.4 Robustness test

In order to ensure the robustness of the research results, this paper adopts the following three methods to conduct robustness tests, and the results are shown in Table 5: First, Model 5 is the exponentiation of the natural logarithm of the total assets, lnA (i.e., lnA), and the results show that the test statistic value of Gov*Tech is -27.574, with a test p-value > 0.1, and it still does not have a significant positive effect. The test statistic value of Gov*Mark is 6.250, test p-value < 0.1, and the test statistic value of Gov*Law is 7.380, test p-value < 0.1, both of which are significantly positive, which indicates that both Gov*Mark and Gov*Law are able to positively promote Tobin's Q. Secondly, Model 6 uses a stepwise regression method, the results show that the coefficient of Gov*Tech is still insignificant, while the coefficients of Gov*Mark (β=6.285, p<0.1) and Gov*Law (β=7.433, p<0.1) are still significant and positive, which supports Hypotheses 5 and 6. Thirdly, excluding listed companies with more than 30 years of establishment, the results show that the coefficient of

Gov*Tech is still insignificant. Tech's coefficient is still insignificant, while Gov*Mark's coefficient (β=6.624, p<0.1) and Gov*Law's coefficient (β=6.847, p<0.1) are still significantly positive. Fourthly, the test of nonlinear effect is used to square the interaction term, and the results are presented in Model8, where the test statistics of (Gov*Tech)2, (Gov*Mark) 2 and (Gov*Law)2 are 145.608, 5.345, and 1.841, respectively, with a p-value of the test >0.01, which indicates that, there is no nonlinear effect between the squared term of the interaction term and the Tobin 'Q does not have a non-linear effect between them and the above four methods ensure the robustness of the findings.

Table 5. Robustness test

Variables	Exponential treatment lnA	Stepwise regression	Nonlinear effects test
	Tobin'Q	Tobin'Q	Tobin'Q
	Model 5	Model 6	Model 8
Control variable			
lnA*	-3.55e-13	0.415	0.247
Pro	-0.173*	-0.172*	-0.166*
Roa	0.449***	0.451***	0.355***
Year	0.060	0.063	0.074
Explanatory variables			
Tech	7.305*	7.271*	10.208**
Mark	4.747**	4.657**	4.827**
Law	2.965**	2.962**	2.460**
Moderating variables			
Gov	-21.281***	-21.362***	-13.636***
Interaction term			
Gov*Tech	-27.574	-27.727	
Gov*Mark	6.250*	6.285*	
Gov*Law	7.380*	7.433*	
$(Gov*Tech)^2$			145.608
$(Gov*Mark)^2$			5.345**
$(Gov*Law)^2$			1.841
R^2	0.413	0.414	0.397
Adj-R^2	0.360	0.361	0.343
F-value	7.810***	7.820***	7.310***
VIF	3.79	3.79	2.51

V. Conclusions and Implications

The conclusions of this paper are as follows: (1) patent high-quality development better reflects the technological innovation of enterprise value, that is, the different dimensions of patent high-quality development are able to promote enterprise value, but with different characteristics, in which the promotion effect of technical quality is better than market quality and legal quality; (2) the degree of state-owned controlling enhances the promotion effect of market and legal quality on enterprise value, that is, the higher the degree of state-owned controlling, the more obvious the promotion effect of market and legal quality on enterprise value. (3) The degree of state ownership enhances the promotion effect of market quality and legal quality on enterprise value, i.e. the higher the degree of state ownership, the more obvious the promotion effect of market quality and legal quality on enterprise value. However, the degree of state ownership does not have a significant positive effect between technology quality and enterprise value; (4) there are significant industry differences in the impact of different dimensions of high-quality patent development on enterprise value.

In response to the conclusions of this paper, this paper manages the following insights: first, in terms of incentive policies. According to the evaluation system for measuring high-value patents, the patents researched and developed by enterprises, colleges and universities as well as scientific research institutes and other institutions should be comprehensively evaluated, and based on the evaluation level, the proportion of invention and authorized patents should be increased, the proportion of designs and utility models should be moderately reduced, the financial subsidies and scientific research incentives for invention and authorized patents should be increased to improve the overall development of high patent quality, and the industry-university-research institutes should be encouraged to carry out in-depth cooperation, and the basic research should be emphasized and developed. Second, in terms of business environment. Secondly, in terms of business environment, implement the business environment of "loose on the outside and tight on the inside", build a good and loose patent market environment, improve the efficiency of R&D and transformation of scientific and technological achievements of intellectual property rights, encourage and support the integration of technology, market and law, and introduce intellectual property agencies into science and technology parks to promote the efficiency of transformation of local scientific and technological achievements, and at the same time, increase the protection of intellectual property rights through the legal department protection of intellectual property rights, through the legal department and market supervision department, to seriously combat intellectual property infringement, to achieve the healthy development of commercialization of technological achievements.

The limitations of this paper are, first, the sample enterprises come from listed enterprises, and it is difficult to obtain such data for non-listed enterprises (e.g. Huawei). Second, the variables selected in this paper do not involve social factors such as human capital, making it difficult to accurately measure the characteristics of R&D talents. Based on this, in the future study, field research and interviews will be used to obtain relevant data to deepen the study of the internal logical relationship between high-quality development of patents and enterprise value.

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