Do patent bubbles exist? Test on innovation situation in China's A - share market

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Abstract: China's expanding patent applicants reflects the results of the innovation catch-up strategy, but there have been persistent doubts about patent bubbles. Using SADF, GSADF and BSADF tests, this paper found that the phenomenon of the patent bubble is not common during the observation period in China's listed companies from 2007 to 2019, and different degrees of patent bubbles occurred only in four industries. China's technology market is still in the stage of innovation accumulation and catch-up.

1 Introduction

Innovation is the primary driving force for development, and protecting intellectual property rights means protecting innovation. Patent is an important part of intellectual property. Since 2011, the number of patent applications from China received by SIPO has been ranked first in the world, which reflects the achievement of China's patent system and innovation strategy. At the same time, the problem of patent quality has gradually emerged, and discussion on the patent bubble has been constantly raised. For a long time, under the innovation incentive from the government, the research and development efficiency of enterprises or research institutions is low, and the patent application motivation is distorted, leading to a large number of low-quality patents flooding the market, and the trend of patent bubble is continuously intensified [1-2]. The development goal of the Chinese technology market changes to achieve the balanced development of patent quantity and quality.

The 14th Five-Year Plan and the 2035 Vision Goals outline the goals for the development of domestic science and technology innovation for China, emphasizing the development of high-value invention patents and squeezing out the patent bubble. This study makes a detailed investigation on the existence, degree, birth time and death time of patent bubbles from the industry level in China.

2 Empirical analysis

2.1 Index construction and data

2.1.1 The Bubble indexation

The ultimate form of patents is intangible assets, whose

real value is difficult to be expressed in numerical terms [3]. R&D investment directly affects the number and scale of patent applications. It is an alternative manner to estimate the unit price or value of patents through R&D investment. This study proposed index I (R&D input per unit patent), which is measured by the ratio of the R&D investment of an enterprise in a certain period and the number of one-period lag patent applications.

The calculation of index I is shown below:

$$I = Y/[X_{-1} * 1000000] \quad (1)$$

Y is the current R&D investment of the enterprise, $X_{(-1)}$ stands for the number of patent applications in one-period lag. I basically reflects the average cost of an enterprise to apply for a patent. The performance of patent bubbles at the industrial level can be obtained by unit root test on this index.

This paper uses the SADF and GSADF time series unit-root test models to test the existence and performance of patent bubbles through I , and uses the BSADF method to investigate the beginning and endpoint of the single, to effectively monitor the evolution process of the patent bubble in various industries [4-5].

2.1.2 The sample data

The financial statement data and patent application data of listed companies in the CSMAR database are selected to construct index I . According to the 2012 version of the industry classification of CSRC, a total of 13 industry samples were obtained by excluding the financial industry (A0 represents the sample of all listed companies excluding the financial industry, as shown in Table 1). The sample interval is from 2007 to 2019. The samples of enterprises whose R&D investment is 0 in the observation interval and the data of a certain year in which the number of patent applications is 0 are excluded.

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Table 1. Industry Codes.

Name of the industry	Code	Name of the industry	Code
Overall samples excluding the financial industry	A0	Agriculture, forestry, animal husbandry and fishery	A7
The mining industry	A1	Industry of wholesale and Retail	A8
Industry of Production and supply of electricity, heat, gas and water	A2	Industry of water conservancy, environment and public facilities management	A9
The real estate industry	A3	Industry of culture, sports and entertainment	A10
The construction industry	A4	Industry of information transmission, software and information technology services	A11
Industry of transportation, warehousing and postal services	A5	Manufacturing	A12
Industry of scientific research and technical services	a6	Industry of leasing and business services	a13

Descriptive statistics of sample data are shown in Table 2.

Table 2. Descriptive statistics of sample data.

Code	Number of firms	Number of samples	Average value	Max value	Min value
A0	2957	17941	6.09	814.90	0
A1	60	424	10.16	516.76	0
A2	79	449	2.65	145.35	0
A3	42	213	3.37	50.79	0
A4	85	525	5.83	150.84	0
A5	61	315	3.13	112.11	0
A6	37	134	5.54	121.98	0
A7	36	197	6.18	223.79	0
A8	83	462	4.98	115.95	0
A9	44	225	3.15	50.83	0
A10	35	145	9.43	269.25	0
A11	241	1322	14.66	788.06	0
A12	2122	13363	5.43	814.90	0
A13	32	167	7.94	317.58	0

2.2 The existence test of patent bubbles

The SADF model is based on the forward recursive right tail ADF test, which can detect periodic bubbles. When the value of the SADF statistic is greater than the critical value, the series of data is considered to be in a bubble. The GSADF model is better at testing multiple continuous bubbles. When the value of the GSADF statistic is greater than the critical value, the price series is considered to have a bubble. Afterward, Phillips et al. [6] proposed the BSADF model to detect the birth and death time points of bubbles.

Table 3. The Test results of I with SADF and GSADF model.

Industry Code	SADF statistics	GSADF statistics
A0	-0.575***	-0.575***
A1	-1.569***	-1.569***
A2	-1.768***	-1.768***
A3	0.267***	0.267***
A4	-4.890***	-2.082***
A5	-1.902***	-1.344***
A6	-0.687***	-0.207***
A7	2.154*	2.154*
A8	-0.854***	-0.854***
A9	0.655***	0.655***
A10	2.262*	2.262*
A11	6.509	6.509
A12	-0.461***	-0.461***
A13	1.142**	1.144***

Notes: The critical values (CV) of SADF and GSADF tests are obtained by 2 000 Monte Carlo simulations.

Table 4. Statistics of SADF test results by industry.

	<90% CV	>90% CV	>95% CV	>99% CV
I	A0, A1, A2, A3, A4, A5, A6, A8, A9, A12	A13	A7, A10	A11

Table 5 shows the statistics of the SADF test results in Table 4. As shown, most of the industries in the sample did not contain patent bubbles during the observation period. However, there were still four industries showing patent bubbles of different degrees, i.e., the leasing and business services (A13), the agriculture, forestry, animal husbandry and fishery (A7) and culture, sports and entertainment (A10), the information transmission, software and information technology service industry (A11).

2.3 Time point test of bubbles

Based on the results of existing tests, it is preliminarily judged that there are patent bubbles in four industries during the observation period. To determine the specific birth and death time of patent bubbles in each industry, the BSADF test is conducted by EvIEWS 9.0.

Fig. 1. The BSADF time marking results of Patent bubbles by industry.

The duration of patent bubbles can be determined by comparing the BSADF statistical sequence with the critical value sequence CV-BSADF at the 95% confidence level, and the size of bubbles is measured by the maximum BSADF statistic. As Figure 2 shown, patent bubbles occurred in the four industries from 2007 to 2019. Among them, A7, A10 and A13 had a complete patent bubble process respectively, while A11 only had a termination of the patent bubble during the observation period, and no corresponding starting point was observed. The duration and extent of bubbles in the industries are different, as shown in Table 6.

Table 5. Statistical results of occurrence of patent bubbles in different industries.

Code	Any patent bubbles ?	Start point	Maximum BSADF statistic	End point	Duration of the bubble
A7	YES	mid - 2013	2.154	the end of 2014	About 1.5 years
A10	YES	2015	2.262	2018	About 3 years
A11	YES	unknown	6.509 in the observation period	2016	unknown
A13	YES	the beginning of 2016	1.144	the end of 2016	About 0.5 year

Data source: Organized according to the trend of BSADF and CV-BSADF statistics as shown in Figure 2.

According to Table 5, in the sample period, the patent bubble in A10 lasted the longest, lasting about 3 years from 2015 to 2018, and the peak of the bubble was relatively high, reaching 2.262 in 2016. Patent bubbles in A7 and A13 are kept and renewed for 1.5 years and about 0.5 years respectively. The former bubble occurred earlier, around 2013 and 2014, with a higher peak of 2.154. The latter was concentrated in 2016 and to a lesser extent, with a peak of 1.144. There was no complete patent bubble cycle in A11 during the observation period, but the degree of the bubble reached the highest 6.509, which appeared in 2013, and the bubble size was far larger than that of the other three industries. This industrial patent bubble lasted for at least four years from 2012 to 2016 (before 2012 is unknown, see Fig. 2). It weakened in 2014, but then expanded a bit before gradually dying out. Concerning this bubble, index I of A11 reached an unprecedented high, rising 453.738% from 2.782 in 2008 to 15.405 in 2016.

Fig. 2. The occurrence of industrial bubbles during the observation period.

Note: Since constraints of the sample, the starting point of the patent bubble in A11 is unknown, as shown in Table 6.

3 Discussions

The empirical analysis shows that there is the phenomenon of the patent bubble in the Chinese market, which has industry differences. From the perspective of industries, the generation of patent bubbles is directly affected by short-term policy incentives, but the root problem lies in the imperfect mechanism of the market.

Patent bubbles are affected by both internal market factors and external policy shocks. The market failure effect is the fundamental internal cause of the patent bubble, which refers to the inherent defects in the market and the inability to allocate resources through an effective price mechanism. The price-discovery mechanism is obviously missing in the design of the patent system, and the patent value information (which may be embodied in patent holding and maintenance costs, patent transaction prices, patent litigation costs, etc.) cannot be truly reflected. China's technology market is immature and the patent price discovery mechanism is inadequate. Thus, R&D departments often take patent applications as the end of R&D, ignoring important links such as patent transformation.

In terms of external impact, short-term incentives brought by innovation policies may distort firms' patent activities, accelerate the market failure effect, and even trigger more new problems.

4 Conclusions

Although the number of patent applications in China has a considerable scale, the proportion of high-quality patents is relatively low, presenting a similar phenomenon of false prosperity. The current state of patent development is not enough to support the transition of China's economy to high-end sectors. Patent bubbles are affected by both internal factors of the market and external policy shocks. The phenomenon of patent bubbles does exist in the Chinese market, but it is not very common. During the observation period, there are only four industries in which the patent bubbles occur, and there are differences in the performance of bubbles in different industries.

It indicates that the strategy of accelerating the construction of intellectual property during the 13th Five-Year Plan years has achieved certain results. There is a huge space for technological progress in most industries in China, and patent development has a good prospect.

References

1. A.J. C. Trappey, C. V. Trappey, C.Y. Wu, C.W. Lin. *Adv. Eng. Inform.* 26, 1 (2012).
2. C.X. Long, J. Wang. *Sci Public Policy*, (2019).
3. C. Mackay. *J. Comp, Neurol.* 430, 4 (2001).
4. G. W. Evans. *Am, Econ, Rev.* 81, 4 (1991).
5. P.C.B. Phillips, J. Yu. *Quan, Eco.* 2 (2011).
6. P.C.B. Phillips, S.P. Shi, J. Yu. *Int, Econ, Rev.* 56, 4 (2015).