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Longer Patent Life Representing Higher Value? A Study on China Stock Market and China Patents

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Abstract

By setting the market capitalization as the frame of patent value reference, twenty-two quarter's market capitalization from 2016Q1 to 2021Q2 of China listed companies (A-shares) were collected. All valid patent data of three patent species including the invention grant, the utility model grant and the design grant, were retrieved for calculating the average patent life of each A-share. The variances of the market capitalization via different patent life groups were analyzed via ANOVA. The A-shares having invention grant's patent lives above the general level usually showed higher market capitalization means than the A-shares having invention grant's patent lives below the general level. The invention grants with longer patent life might be regarded as the patents of higher value. The utility model grants with longer patent life might not be regarded as the patents of higher value because of poor significance. The design grant's patent life was a significant indicator for discriminating China A-share's market capitalization, however, the optimal patent life were close to but not longer than four years. The longer patent life of the design grants was not regarded as higher value.

JEL classification numbers: C38, C46, G11, G12.
Keywords: patent, market capitalization, China A-share, patent life, ANOVA.

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1 Introduction

China is now the world No.2 economy and has a stock market with the world No.2 transaction volume. In the meantime, China has been the world largest patent application country. There are more than 4.6 million of patents granted by China National Intellectual Property Administration (CNIPA) in single year of 2021. CNIPA therefore announces five criteria for identifying the "high value" patents, wherein, one of the criteria is "A valid invention grant of patent life more than ten years". The patent life suddenly becomes a discussing issue.

The essence behind patent is innovation. Innovation is a driver of economic progress that benefits companies, businesses and the economy as a whole. Most economists agree that technological innovation is a key driver of economic growth, and the stock market usually reflects the economic conditions of an economy. The innovation behaviour and the patent trend of listed companies in the stock market usually followed by those unlisted companies and individuals.

Though the relationships between the financial behaviour of Chinese companies and China patents were discussed (Motohashi, 2009; Hu & Jefferson, 2009; Lei, Zhao & Zhang et al., 2011; Liu & Qiu, 2016; Dang & Motohashi, 2015; Chen & Zhang, 2019), however, these companies were not listed companies so the research results might only be partly convinced because it is well known that the financial information of most unlisted companies in China has always been adjusted a lot for minimizing tax payment.

With regard to the listed companies and patents, He, Tong & Zhang et al. (2016) constructed a China patent database of all China listed companies and their subsidiaries from 1990 to 2010. Chen, Wei & Che (2018, 2020) discussed China patent data and the stock price data of China listed companies in Shanghai main board from 2011 to 2017 and found some patent indicators have the leading effects on the stock price. Chiu, Chen & Che (2020a, 2020b) focused on the whole China stock market data from 2016Q4 to 2018Q3. They found that some patent indicators also have the leading effect on the other financial indicators such as return-on-asset (ROA), return-on-equity (ROE), book-value-per-share (BPS), earnings-per-share (EPS), price-to-book (PB) and price-to-earnings (PE). They also proposed the patent prediction equations for quantitatively giving the predictive values of the aforementioned financial indicators.

Chiu, Chen & Che (2020c, 2020d, 2020e, 2020f, 2021), Li, Deng & Che (2020a, 2020b, 2021) further studied the patent leading effect on various stock boards of China, proposed each stock board's patent prediction equations on the stock price, ROA, ROE, BPS, EPS, PB and PE, finally proposed patent based stock selection criteria to have stock portfolio performance surpassing the market trend.

Tsai, Che & Bai (2021a, 2021b, 2021c, 2021d, 2021e, 2021f, 2022) discussed the relationship between various China patent indicators and the performance of China listed companies (A-shares). The China A-shares with the higher innovation continuity are found to show higher stock return rate mean no matter what patent species (Tsai et al., 2021a). The A-shares having patents of the higher patent count are found to show higher stock price mean and higher stock return rate mean (Tsai et al., 2021b, 2021f). The A-shares having patents of the higher technology variety are found to show higher stock return rate mean (Tsai et al., 2021c). The A-shares having patent grants of the longer examination duration are found to show higher stock return rate mean (Tsai et al., 2021d). The A-shares having higher backward citation counts are found to show higher stock price means than the A-shares of lower backward citation counts (Tsai et al., 2021e). The A-shares of higher forward citation counts are found to show lower stock price means than the A-shares free of forward citation counts (Tsai et al., 2022).

Patent life is an important issue in China. For the purpose of boosting innovation, some local governments in China subsidized the applicants for filing new patent applications many years ago. Lots of companies applied a large number of patents for getting subsidies then gave up unimportant patents when the annual fees were due. Consequently, the subsidy policy is modified and focuses on encouraging those long-life patents having been paid the maintenance fees for many years.

On the other hand, the patent life of US patents has been studied for years. It was applied as an indicator for patent licensing (Lee, 2008) and patent valuation (Lai & Che, 2009a, 2009b, 2009c). O'Donoghue, Scotchmer & Thisse (2004) found that patent life depends on patent breadth. Koo & Wright, (2010) found if licensing is negotiated ex post, optimal patent life may be finite under competition. Van Zeebroeck (2011)

studied EP patents and found the life expectancy of patent rights has significantly increased over the past decades. Liu, Cao & Song (2014) found that the value of Chinese agricultural patents, measured by their patent life span and renewal length, has been improving.

However, the study on China patent life and its contribution to the applicant is not studied yet. The patent life's effect on the company's performance, especially the financial performance has not been discussed. Are the patents of longer lives more valuable than the patents of shorter lives? Do all the patent species have the similar patent life effect? It is the objective of this research to find out the aforementioned questions by observing the patent life's effect on the market capitalization of China A-shares.

In the following paragraphs, section 2 presents the data and methodology including the patent and financial data used, the defined patent life groups, the effective sample statistics, and the applied statistical test; section 3 presents the result and finding on the patent life of various patent species including the invention grant, the utility model grant and the design grant; section 4 presents the conclusion and recommendation.

2 Data and Methodology

2.1 Company Integrated Patent Database

It is a common phenomenon that a listed company has lots subsidiaries. Some patents are owned by the parent company, some patents are owned by the subsidiaries, some patents are co-owned by the parent company and the subsidiaries. When a subsidiary's revenue is merged to its parent company as shown in the formal financial report, the subsidiary's patents are inferred in this research to contribute to parent company's financial performance. Therefore, a company integrated patent database is built in this research to make all subsidiaries' patents being merged together with parent company's patents, while the original China patent raw data and the legal status data thereof are supplied by CNIPA. Furthermore, if a patent is co-owned by parent company and any of the subsidiaries, it is regarded as a single one patent of the parent company for avoiding duplicated calculation. However, if a patent is co-owned by two or more parent A-shares, it is inferred to contribute equivalently to each parent A-share's financial performance, so the patent is duplicated and specified to each of the co-owning A-shares.

2.2 Patent Species and Patent Life

There are four species of published patents in China including the invention publication, the invention grant, the utility model grant, and the design grant. It is not necessary to discuss the patent life of the invention publication because it would be invalid either it does not request for substantial examination before the legal due date or it requests for the substantial examination but fails to pass. The invention grant which being the only species passing both the preliminary examination and the substantial examination is always regarded as the most valuable. The utility model grant and the design grant just need to pass the preliminary examination. According to the patent regulations announced by CNIPA, the annual fee is not necessary to pay before a patent is granted. When a patent is granted or receives the notice of allowance, the annual fee must be paid to the government periodically to maintain its validity. The valid patents are therefore regarded as more important than the invalid patents. In this research, all valid China patents of each A-share over all previous years by the end of each quarter from 2016Q1 to 2021Q2 are collected and discussed.

For each of twenty-two quarters from 2016Q1 to 2021Q2, the patent life of a patent is defined as the time period from the patent filing date to the end of said quarter. The patent life of an A-share is the average patent life of all its valid patents according to the specific patent species and the specific quarter. It is important to note that if a patent is invalid in 2016Q2 but it is valid before 2016Q1, this patent should be included to calculate patent life for 2016Q1 and excluded to calculate patent life for 2016Q2.

For each patent species in any quarter, four patent life groups are defined by the percentile rank of all effective samples' patent lives. The patent life group #1 consists of the effective samples having patent lives of PR 0~25; the life group #4 consists of the effective samples having patent lives of PR 75~100; the patent life groups #2, #3 and so forth. Hence, the effective samples in groups #1 and #2 have the patent life means below the general level while the effective samples in groups #3 and #4 have the patent life means

above the general level. In addition, the A-shares free of patents are further set as the group #0 for cross comparison.

2.3 Market Capitalization

In order to discuss whether longer patent life corresponds to higher patent value, the market capitalization of China A-shares are as the frame of A-share's patent value reference. The relationship between China patent life and China A-share's market capitalization is tested in this research. market capitalization is calculated by multiplying the number of stock shares outstanding by the price of a single stock share. market capitalization is more often used than the stock price and/or the stock return rate to define the value and/or the financial achievement of a company when analyzing potential investment opportunities. Therefore, the market capitalization is set as the frame of value reference with regard to the patent life in this research.
Since market capitalization is varying according to stock trading. Hence, the market capitalization in the end of the last trading day of each quarter from 2016Q1 to 2021Q2 is selected and discussed.

2.4 Population and Sample

The population consists of China A-shares listed in shanghai stock exchange and Shenzhen stock exchange. The China companies listed in Hong Kong or overseas are excluded. An effective sample must meet the following condition: It is listed to have a definite closing price and corresponding market capitalization in the end of the last trading day of any quarter from 2016Q1 to 2021Q2.
By the end of 2021Q2, there are 4,362 effective samples of China A-shares selected in this research. Table 1 shows the number of A-shares in each quarter from 2016Q1 to 2021Q2.

Table 1: A-shares statistics from 2016Q1 to 2021Q2

	Number of A-shares			
Year	Q1	Q2	Q3	Q4
2016	2,775	2,809	2,874	2,975
2017	3,110	3,221	3,326	3,414
2018	3,451	3,477	3,503	3,521
2019	3,554	3,585	3,647	3,721
2020	3,772	3,838	4,015	4,117
2021	4,217	4,362		

Data: Author's calculation

2.5 Analysis of Variance (ANOVA)

Analysis of Variance (ANOVA) is applied for discovering whether the patent life significantly corresponds to the market capitalization or not. ANOVA is a statistical approach used to compare variances across the means of different data groups. The outcome of ANOVA is the "F-statistic".

$$F = \frac{MST}{MSE} = \frac{\sum n_j (\overline{x_j} - \bar{x})^2 / (k-1)}{\sum\sum (x - \overline{x_j})^2 / (N-k)} \quad (1)$$

This ratio shows the difference between the within group variance and the between group variance, which ultimately produces a result which allowing a conclusion that the null hypothesis H_0: $\mu_1 = \mu_2 = ... = \mu_k$ is supported or rejected. If there is a significant difference between the groups, the null hypothesis is not supported, and the F-ratio will be larger and the corresponding p value is smaller than 0.05.

3 Result and Finding

3.1 Invention Grant

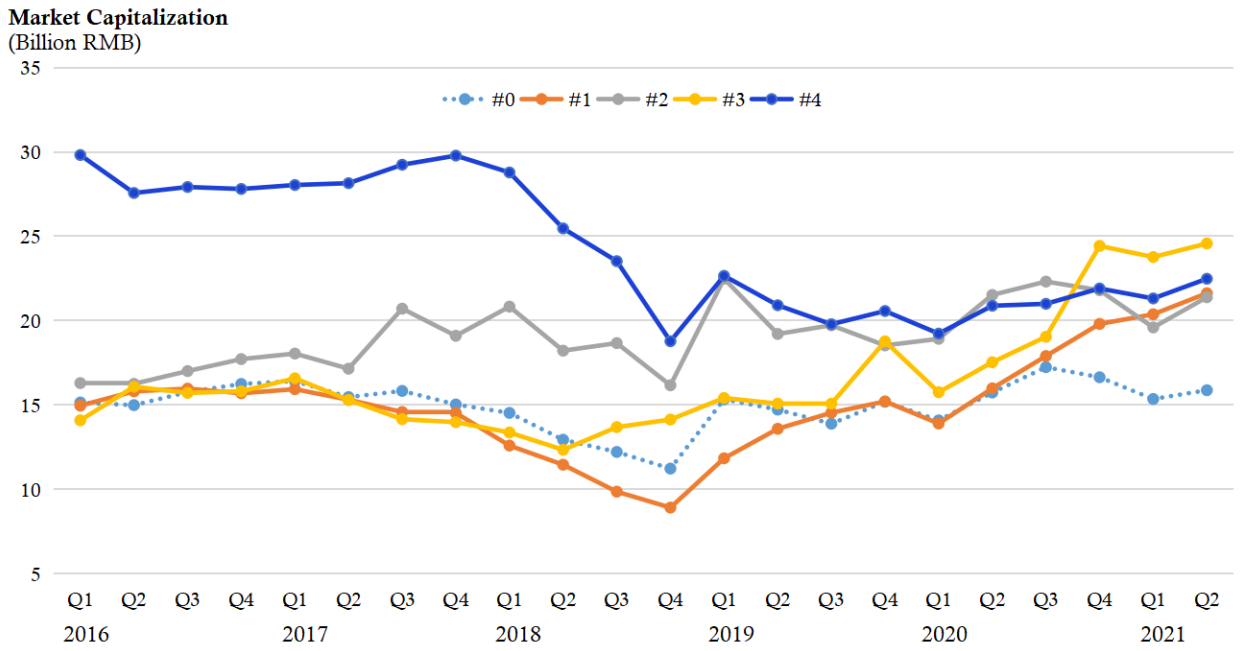
Table 2 shows the patent life means of each invention grant's patent life group. It seems that the patent life mean of each patent life group shows an increasing trend from 2016Q1 to 2021Q2.

Table 2: Patent life mean of each invention grant's patent life group

		Patent life mean (year)			
Year	Quarter	Group #1	Group #2	Group #3	Group #4
2016	Q1	3.22	4.38	5.30	7.23
	Q2	3.25	4.39	5.29	7.21
	Q3	3.27	4.39	5.30	7.22
	Q4	3.44	4.57	5.45	7.37
2017	Q1	3.39	4.56	5.45	7.40
	Q2	3.41	4.62	5.49	7.47
	Q3	3.43	4.67	5.58	7.54
	Q4	3.43	4.70	5.62	7.57
2018	Q1	3.52	4.77	5.71	7.62
	Q2	3.54	4.84	5.78	7.67
	Q3	3.59	4.92	5.87	7.76
	Q4	3.66	5.02	5.98	7.87
2019	Q1	3.71	5.09	6.07	7.99
	Q2	3.77	5.17	6.16	8.08
	Q3	3.80	5.27	6.26	8.20
	Q4	3.87	5.35	6.37	8.33
2020	Q1	3.95	5.47	6.51	8.46
	Q2	3.95	5.52	6.59	8.56
	Q3	3.84	5.52	6.63	8.63
	Q4	3.77	5.51	6.67	8.67
2021	Q1	3.70	5.51	6.71	8.75
	Q2	3.61	5.48	6.74	8.78

Data: Author's calculation

Figure 1 shows the market capitalization means (in billion RMB) of invention grant's patent life groups. Among twenty-two quarters from 2016Q1 to 2021Q2, group #4 shows the highest market capitalization means in seventeen quarters; group #1 shows the lowest market capitalization means in thirteen quarters. It seems that the longest patent life group shows the highest market capitalization mean while the shortest patent life group shows the lowest market capitalization mean. Meanwhile, the A-shares without patents, i.e. group #0, seems to show higher market capitalization mean than the A-shares of the shortest patent life group, i.e. group #1, in most quarters. However, it needs to be further confirmed.



Data: Author's calculation

Figure 1: Market capitalization means of invention grant's patent life groups

Table 3 shows the results of ANOVA on the market capitalization between invention grant's patent life groups from 2016Q1 to 2021Q2. The market capitalization variances between patent life groups in all quarters from 2016Q1 to 2019Q1 are of significance. The market capitalization variances between patent life groups in all quarters from 2019Q2 to 2021Q2 are free of significance. In total of twenty-two quarters from 2016Q1 to 2021Q2, there are thirteen quarters in which the market capitalization variances between patent life groups are of significance. The rate of significance is higher than 50%. However, for the recent nine quarters, the market capitalization variances are free of significance though the market capitalization means are different as shown in Figure 1. It means that different invention grant's patent life groups had significantly different market capitalization means previously, whereas the market capitalization differences are not significant recently.

Table 3: Result of ANOVA on market capitalization between Invention grant's patent life groups

			Market capitalization (billion RMB)			
Year	Quarter	Patent life group	Sum square	Mean square	F	p
2016	Q1	between groups	85,674.7	21,418.7	5.531	0.001***
		within groups	10,726,283.8	3,872.3		
	Q2	between groups	57,613.9	14,403.5	3.861	0.004**
		within groups	10,459,435.5	3,730.2		
	Q3	between groups	59,070.8	14,767.7	3.858	0.004**
		within groups	10,980,986.5	3,827.5		
	Q4	between groups	57,996.1	14,499.0	3.614	0.006**
		within groups	11,914,745.2	4,011.7		
2017	Q1	between groups	59,991.6	14,997.9	3.411	0.009**
		within groups	13,651,859.1	4,396.7		
	Q2	between groups	74,666.5	18,666.6	3.887	0.004**

		within groups	15,442,465.9	4,801.8		
	Q3	between groups	100,132.1	25,033.0	4.546	0.001***
		within groups	18,287,971.1	5,506.8		
	Q4	between groups	114,160.4	28,540.1	4.660	0.001***
		within groups	20,879,880.1	6,124.9		
2018	Q1	between groups	123,031.9	30,758.0	5.285	0.001***
		within groups	20,056,880.7	5,820.3		
	Q2	between groups	92,318.2	23,079.6	4.797	0.001***
		within groups	16,704,282.3	4,811.1		
	Q3	between groups	82,001.0	20,500.3	3.586	0.006**
		within groups	19,997,578.8	5,716.9		
	Q4	between groups	42,151.5	10,537.9	2.413	0.047*
		within groups	15,356,725.2	4,367.7		
2019	Q1	between groups	64,332.3	16,083.1	2.838	0.023*
		within groups	20,113,979.8	5,667.5		
	Q2	between groups	28,535.9	7,134.0	1.181	0.317
		within groups	21,627,607.2	6,041.2		
	Q3	between groups	24,665.5	6,166.4	1.092	0.359
		within groups	20,571,313.6	5,648.4		
	Q4	between groups	16,767.1	4,191.8	0.684	0.603
		within groups	22,772,168.9	6,128.1		
2020	Q1	between groups	19,889.3	4,972.3	1.058	0.376
		within groups	17,709,530.7	4,701.2		
	Q2	between groups	22,649.1	5,662.3	1.083	0.363
		within groups	20,043,586.0	5,229.2		
	Q3	between groups	14,331.6	3,582.9	0.613	0.653
		within groups	23,419,443.0	5,840.3		
	Q4	between groups	25,817.1	6,454.3	0.894	0.466
		within groups	29,681,023.1	7,218.1		
2021	Q1	between groups	28,725.6	7,181.4	0.994	0.410
		within groups	30,437,265.4	7,226.3		
	Q2	between groups	31,255.7	7,813.9	1.080	0.365
		within groups	31,529,568.5	7,236.5		

p*<0.05, p**≤0.01, p***≤0.001; Data: Author's calculation

For those thirteen quarters in which the market capitalization variances between invention grant's patent life groups are of significance, Table 4 further shows the multiple comparisons of ANOVA on market capitalization between group #4 and the other groups in order to find out which patent life group has higher or lower market capitalization mean.

Table 4: Multiple comparisons of ANOVA on market capitalization between invention grant's patent life groups

				Market capitalization (billion RMB)		
Year	Quarter	(I) Group	(J) Group	Mean difference (I-J)	Standard error	p
2016	Q1	#4	#0	14.669	3.555	0.001***
		#4	#1	14.855	4.040	0.001***
		#4	#2	13.518	4.040	0.001***
		#4	#3	15.726	4.044	0.001***
	Q2	#4	#0	12.574	3.472	0.001***
		#4	#1	11.757	3.908	0.003**
		#4	#2	11.312	3.908	0.004**
		#4	#3	11.483	3.912	0.003**
	Q3	#4	#0	12.154	3.484	0.001***
		#4	#1	11.950	3.882	0.002**
		#4	#2	10.908	3.884	0.005**
		#4	#3	12.202	3.888	0.002**
	Q4	#4	#0	11.557	3.509	0.001***
		#4	#1	12.108	3.900	0.002**
		#4	#2	10.085	3.902	0.010**
		#4	#3	11.991	3.906	0.002**
2017	Q1	#4	#0	11.624	3.601	0.001***
		#4	#1	12.100	3.968	0.002**
		#4	#2	9.990	3.970	0.012*
		#4	#3	11.458	3.972	0.004**
	Q2	#4	#0	12.677	3.710	0.001***
		#4	#1	12.835	4.043	0.002**
		#4	#2	10.993	4.043	0.007**
		#4	#3	12.849	4.048	0.002**
	Q3	#4	#0	13.405	3.916	0.001***
		#4	#1	14.655	4.247	0.001***
		#4	#2	8.530	4.247	0.045*
		#4	#3	15.081	4.251	0.001***
	Q4	#4	#0	14.750	4.098	0.001***
		#4	#1	15.251	4.382	0.001***
		#4	#2	10.680	4.384	0.015*
		#4	#3	15.797	4.389	0.001***
2018	Q1	#4	#0	14.251	3.976	0.001***
		#4	#1	16.187	4.243	0.001***
		#4	#2	7.952	4.243	0.061
		#4	#3	15.413	4.248	0.001***
	Q2	#4	#0	12.524	3.620	0.001***
		#4	#1	14.004	3.818	0.001***
		#4	#2	7.246	3.820	0.058
		#4	#3	13.122	3.824	0.001***

	Q3	#4	#0	11.308	3.944	0.004**
		#4	#1	13.661	4.134	0.001***
		#4	#2	4.856	4.134	0.240
		#4	#3	9.836	4.139	0.018*
	Q4	#4	#0	7.548	3.451	0.029*
		#4	#1	9.858	3.589	0.006**
		#4	#2	2.609	3.589	0.467
		#4	#3	4.640	3.593	0.197
2019	Q1	#4	#0	7.318	3.929	0.063
		#4	#1	10.813	4.055	0.008**
		#4	#2	0.171	4.056	0.966
		#4	#3	7.238	4.059	0.075

p*<0.05, p**≤0.01, p***≤0.001; Data: Author's calculation

According to Table 4, from 2016Q1 to 2017Q4, the market capitalization variances between groups #4 and #0, between groups #4 and #1, between groups #4 and #2, between groups #4 and #3, are all of significance. From 2018Q1 to 2018Q3, the market capitalization variances between groups #4 and #0, between groups #4 and #1, between groups #4 and #3, are of significance; whereas the market capitalization variances between groups #4 and #2 are free of significance. In 2018Q4, the market capitalization variances between groups #4 and #0, between groups #4 and #1, are of significance whereas the other market capitalization variances are free of significance. In 2019Q1, the market capitalization variance between groups #4 and #1 is of significance whereas the other market capitalization variances are free of significance.

According to the significant mean differences, groups #4 have the highest market capitalization in all thirteen quarters, groups #1 have the lowest market capitalization in eleven quarters. In summary, for those thirteen quarters in which the market capitalization variances between invention grant's patent life groups are of significance, the A-shares with patent lives above the general level, i.e. groups #3 and #4, usually show higher market capitalization means than the A-shares with patent lives below the general level, i.e. groups #1 and #2. Meanwhile, the A-shares in the longest patent life group, i.e. group #4, always show the highest market capitalization means. Before 2019Q1, the invention grants with longer patent lives might be regarded as the patents of higher value. However, the invention grants with longer patent lives are not appropriately regarded as the patents of higher value since 2019Q2. In addition, the patent life mean of group #4 in 2019Q1 is 7.99, which is quite less 10. The CNIPA's high value patent criteria of ten years patent life might need be adjusted.

3.2 Utility Model Grant

Table 5 shows the patent life means in each utility model grant's patent life group. It seems that the patent life mean of each patent life group shows an increasing trend from 2016Q1 to 2022Q4, whereas the increasing trend stops since 2020Q2.

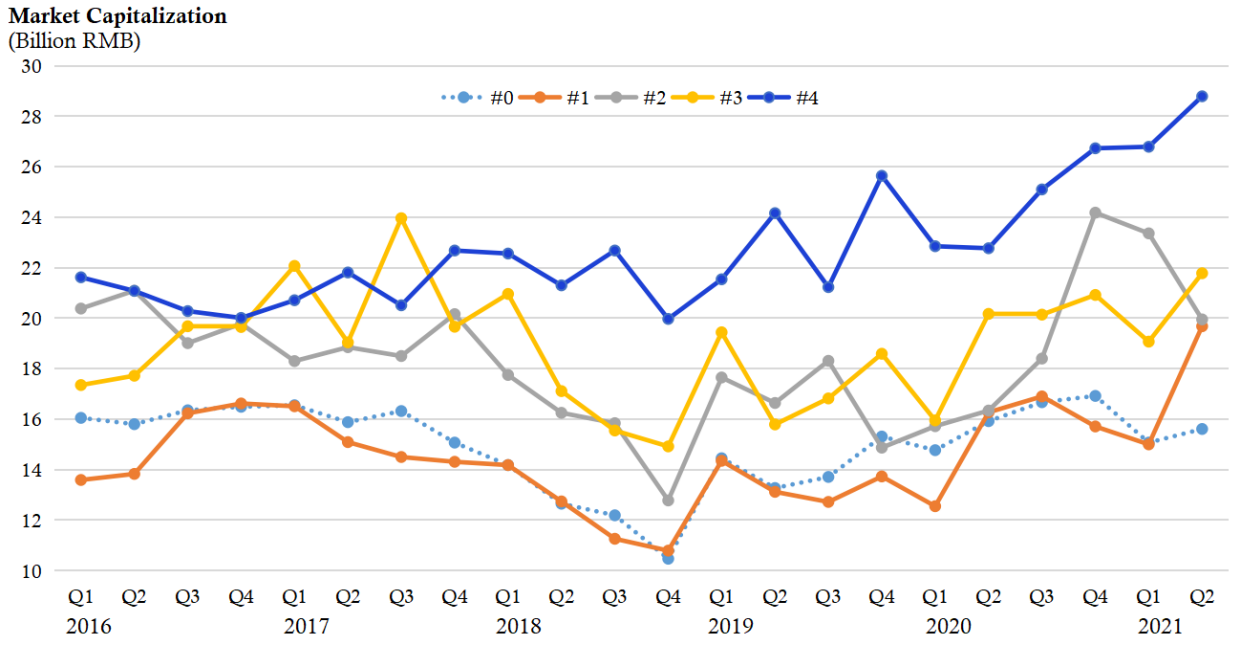
Table 5: Patent life means in utility model grant's patent life groups

		Patent life mean (year)			
Year	Quarter	Group #1	Group #2	Group #3	Group #4
2016	Q1	1.61	2.78	3.53	4.83
	Q2	1.63	2.79	3.56	4.89
	Q3	1.62	2.81	3.63	4.99
	Q4	1.66	2.84	3.65	5.04
2017	Q1	1.71	2.86	3.70	5.13
	Q2	1.71	2.86	3.71	5.16

	Q3	1.75	2.91	3.76	5.18
	Q4	1.79	2.96	3.82	5.21
2018	Q1	1.80	2.96	3.84	5.25
	Q2	1.81	2.95	3.84	5.26
	Q3	1.85	2.99	3.85	5.29
	Q4	1.86	3.02	3.88	5.34
2019	Q1	1.90	3.06	3.93	5.41
	Q2	1.94	3.09	3.95	5.44
	Q3	1.99	3.11	3.94	5.48
	Q4	2.01	3.13	3.95	5.47
2020	Q1	2.08	3.21	4.02	5.54
	Q2	2.00	3.16	3.98	5.51
	Q3	1.93	3.11	3.95	5.45
	Q4	1.95	3.11	3.93	5.41
2021	Q1	1.93	3.05	3.90	5.39
	Q2	2.04	3.10	3.87	5.27

Data: Author's calculation

Figure 2 shows the market capitalization means (in billion RMB) of utility model grant's patent life groups. Among twenty-two quarters from 2016Q1 to 2021Q2, group #4 shows the highest market capitalization means in twenty quarters, groups #0 and #1 show lower market capitalization means in all quarters. It seems that the longest patent life group shows the highest market capitalization mean while the shortest patent life group and the patent-free group show lower market capitalization means. However, it needs to be further confirmed.



Data: Author's calculation

Figure 2: Market capitalization means of utility model grant's patent life groups

Table 6 shows the results of ANOVA on the market capitalization between utility model grant's patent life groups from 2016Q1 to 2021Q2. The market capitalization variances between patent life groups in all quarters in 2016 and 2017 are free of significance. In 2018, the market capitalization variances between patent life groups are of significance in Q3 and Q4 whereas the market capitalization variances in Q1 and Q2 are free of significance. In 2019, the market capitalization variances between patent life groups are of significance in Q2 and Q4 whereas the market capitalization variances in Q1 and Q3 are free of significance. In 2020, the market capitalization variances between patent life groups are of significance in Q1 and Q4 whereas the market capitalization variances in Q2 and Q3 are free of significance. In 2021, the market capitalization variances between patent life groups are of significance in Q1 and Q2.
In total of twenty-two quarters from 2016Q1 to 2021Q2, there are only eight quarters in which the market capitalization variances between utility model grant's patent life groups are of significance. The rate of significance is lower than 50%.

Table 6: Result of ANOVA on market capitalization between utility model grant's patent life groups

			Market capitalization (billion RMB)			
Year	Quarter	Patent life group	Sum square	Mean square	F	p
2016	Q1	between groups	21,931.8	5,482.9	1.408	0.229
		within groups	10,790,026.7	3,895.3		
	Q2	between groups	22,191.2	5,547.8	1.482	0.205
		within groups	10,494,858.1	3,742.8		
	Q3	between groups	8,434.3	2,108.6	0.548	0.700
		within groups	11,031,622.9	3,845.1		
	Q4	between groups	7,888.2	1,972.0	0.490	0.743
		within groups	11,964,853.2	4,028.6		
2017	Q1	between groups	15,422.0	3,855.5	0.875	0.478
		within groups	13,677,177.3	4,406.3		
	Q2	between groups	18,616.2	4,654.1	0.966	0.425
		within groups	15,498,516.2	4,819.2		
	Q3	between groups	35,376.6	8,844.1	1.600	0.171
		within groups	18,352,726.7	5,526.3		
	Q4	between groups	34,680.9	8,670.2	1.410	0.228
		within groups	20,959,359.6	6,148.2		
2018	Q1	between groups	40,658.8	10,164.7	1.739	0.138
		within groups	20,139,253.8	5,844.2		
	Q2	between groups	35,562.4	8,890.6	1.842	0.118
		within groups	16,761,038.2	4,827.5		
	Q3	between groups	55,894.8	13,973.7	2.441	0.045*
		within groups	20,023,685.1	5,724.3		
	Q4	between groups	42,439.6	10,609.9	2.429	0.046*
		within groups	15,356,437.2	4,367.6		
2019	Q1	between groups	27,891.0	6,972.8	1.228	0.297
		within groups	20,150,421.2	5,677.8		
	Q2	between groups	57,834.3	14,458.6	2.401	0.048*
		within groups	21,549,917.9	6,021.2		
	Q3	between groups	34,797.4	8,699.4	1.541	0.188
		within groups	20,561,181.7	5,645.6		

	Q4	between groups	69,809.1	17,452.3	2.855	0.022*
		within groups	22,719,127.0	6,113.9		
2020	Q1	between groups	45,460.2	11,365.0	2.421	0.046*
		within groups	17,683,959.8	4,694.4		
	Q2	between groups	28,563.3	7,140.8	1.366	0.243
		within groups	20,037,671.9	5,227.7		
	Q3	between groups	38,410.1	9,602.5	1.646	0.160
		within groups	23,395,364.5	5,834.3		
	Q4	between groups	72,165.9	18,041.5	2.503	0.040*
		within groups	29,634,674.2	7,206.9		
2021	Q1	between groups	88,928.6	22,232.2	3.083	0.015*
		within groups	30,377,062.4	7,212.0		
	Q2	between groups	77,327.0	19,331.8	2.675	0.030*
		within groups	31,483,497.3	7,226.0		

p*<0.05, p**≤0.01, p***≤0.001; Data: Author's calculation

For those eight quarters in which the market capitalization variances between utility model grant's patent life groups are of significance, Table 7 further shows the multiple comparisons of ANOVA on market capitalization between group #4 and the other groups in order to find out which patent life group has higher market capitalization.

Table 7:Multiple comparisons of ANOVA on market capitalization between utility model grant's patent life groups

				Market capitalization (billion RMB)		
Year	Quarter	(I) Group	(J) Group	Mean difference (I-J)	Standard error	p
2018	Q3	#4	#0	10.489	3.998	0.009**
		#4	#1	11.422	4.085	0.005**
		#4	#2	6.843	4.085	0.094
		#4	#3	7.132	4.090	0.081
	Q4	#4	#0	9.507	3.506	0.007**
		#4	#1	9.183	3.541	0.010**
		#4	#2	7.198	3.543	0.042*
		#4	#3	5.052	3.545	0.154
2019	Q2	#4	#0	10.883	4.124	0.008**
		#4	#1	11.039	4.091	0.007**
		#4	#2	7.516	4.093	0.066
		#4	#3	8.361	4.095	0.041*
	Q4	#4	#0	10.334	4.104	0.012*
		#4	#1	11.912	4.031	0.003**
		#4	#2	10.778	4.031	0.008**
		#4	#3	7.056	4.035	0.080
2020	Q1	#4	#0	8.079	3.584	0.024*
		#4	#1	10.293	3.500	0.003**
		#4	#2	7.131	3.501	0.042*
		#4	#3	6.898	3.504	0.049*

	Q4	#4	#0	9.807	4.388	0.025*
		#4	#1	11.017	4.090	0.007**
		#4	#2	2.544	4.092	0.534
		#4	#3	5.807	4.095	0.156
2021	Q1	#4	#0	11.719	4.319	0.007**
		#4	#1	11.790	4.135	0.004**
		#4	#2	3.428	3.956	0.386
		#4	#3	7.720	3.961	0.051
	Q2	#4	#0	13.183	4.321	0.002**
		#4	#1	9.113	3.960	0.021*
		#4	#2	8.842	3.961	0.026*
		#4	#3	7.011	3.965	0.077

p*<0.05, p**≤0.01, p***≤0.001; Data: Author's calculation

In 2018Q3, the market capitalization variances between groups #4 and #0, between groups #4 and #1, are of significance whereas the market capitalization variances between group #4 and the other groups are free of significance. In 2018Q4, the market capitalization variances between groups #4 and #0, between groups #4 and #1, between groups #4 and #2, are of significance whereas the market capitalization variance between groups #4 and #3 is free of significance. In 2019Q2, the market capitalization variances between groups #4 and #0, between groups #4 and #1, between groups #4 and #3, are of significance whereas the market capitalization variance between groups #4 and #2 is free of significance. In 2019Q4, the market capitalization variances between groups #4 and #0, between groups #4 and #1, between groups #4 and #2, are of significance whereas the market capitalization variance between groups #4 and #3 is free of significance. In 2020Q1, the market capitalization variances between group #4 and the other groups are all of significance. In 2020Q4 and 2021Q1, the market capitalization variances between groups #4 and #0, between groups #4 and #1, are of significance whereas the market capitalization variances between groups #4 and the other groups are free of significance. In 2021Q2, the market capitalization variances between groups #4 and #0, between groups #4 and #1, between groups #4 and #2, are of significance whereas the market capitalization variance between groups #4 and #3, is free of significance.

According to the significant mean differences, groups #4 have the highest market capitalization in all of eight quarters, groups #1 have the lowest market capitalization in six quarters while groups #0 have the lowest market capitalization in two quarters. In summary, for those eight quarters in which the market capitalization variances between utility model grant's patent life groups are of significance, the A-shares with patent lives above the general level, i.e. groups #3 and #4, usually show higher market capitalization means than the A-shares with patent lives below the general level, i.e. groups #1 and #2. Meanwhile, the A-shares in the longest patent life group always show the highest market capitalization means. However, for twenty-two quarters from 2016Q1 to 2021Q2, there are only eight quarters in which the market capitalization variances between utility model grant's patent life groups are of significance, the utility model grants with longer patent life might not be appropriately regarded as the patents of higher value.

3.3 Design Grant

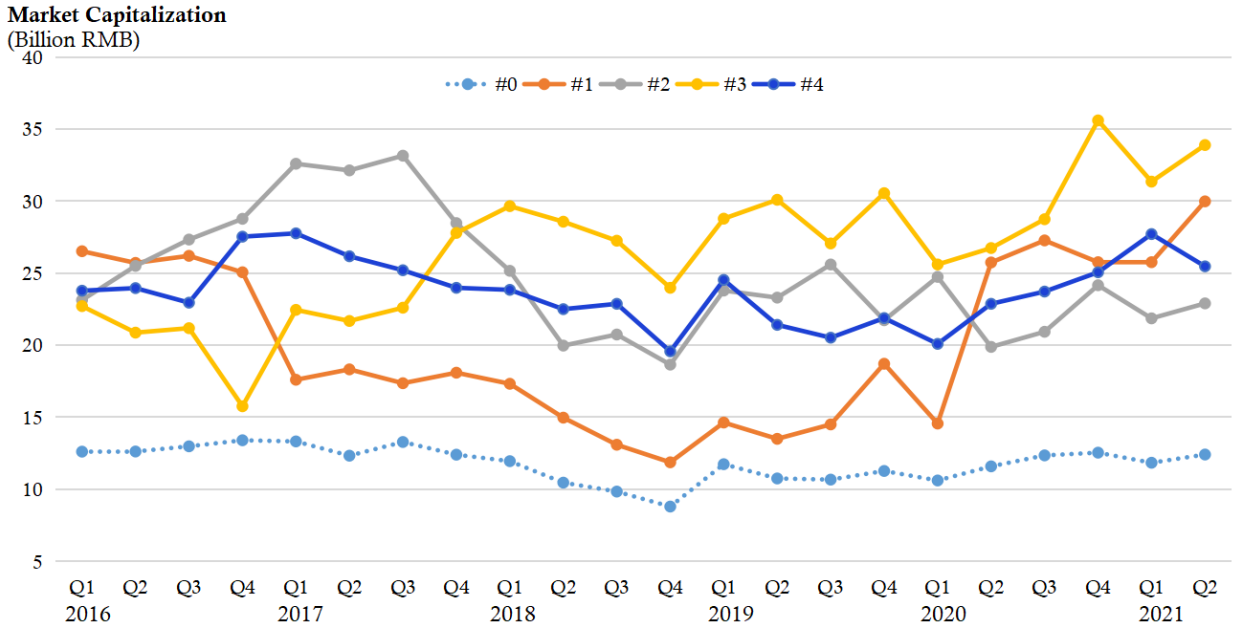
Table 8 shows the patent life means in each design grant's patent life group. Unlike the invention grant and the utility model grant, the design grant's patent life means do not show an increasing trend.

Table 8: Patent life means in design grant's patent life groups

		Patent life mean (year)			
Year	Quarter	Group #1	Group #2	Group #3	Group #4
2016	Q1	1.44	2.78	3.83	6.05
	Q2	1.41	2.77	3.81	6.03
	Q3	1.39	2.74	3.83	6.01
	Q4	1.39	2.71	3.79	5.94
2017	Q1	1.37	2.68	3.78	5.95
	Q2	1.38	2.68	3.77	5.84
	Q3	1.35	2.68	3.79	5.84
	Q4	1.37	2.63	3.76	5.82
2018	Q1	1.40	2.62	3.76	5.81
	Q2	1.41	2.60	3.75	5.86
	Q3	1.43	2.66	3.79	5.89
	Q4	1.44	2.70	3.81	5.95
2019	Q1	1.49	2.75	3.86	6.00
	Q2	1.44	2.75	3.85	5.91
	Q3	1.54	2.81	3.90	6.01
	Q4	1.51	2.79	3.91	6.00
2020	Q1	1.50	2.80	3.91	5.98
	Q2	1.44	2.71	3.84	5.90
	Q3	1.39	2.66	3.81	5.84
	Q4	1.43	2.68	3.81	5.84
2021	Q1	1.43	2.69	3.83	5.85
	Q2	1.40	2.64	3.79	5.80

Data: Author's calculation

Figure 3 shows the market capitalization means (in billion RMB) of design grant's patent life groups from 2016Q1 to 2021Q2. It seems that group #0 shows the lowest market capitalization mean in all quarters while group #3 shows the highest market capitalization mean in most quarters. Unlike the invention grant and the utility model grant, group #4 does not show apparently higher market capitalization mean.



Data: Author's calculation

Figure 3: Market capitalization means in design grant's patent life groups

Table 9 shows the results of ANOVA on the market capitalization between design grant's patent life groups from 2016Q1 to 2021Q2. The market capitalization variances between patent life groups in all quarters from 2016Q1 to 2021Q2 are of significance. The rate of significance is 100%, which is higher than that of either the invention grant or the utility model grant. It means that different design grant's patent life groups had significantly different market capitalization means.

Table 9: Result of ANOVA on market capitalization between design grant's patent life groups

			Market capitalization (billion RMB)			
Year	Quarter	Patent life group	Sum square	Mean square	F	p
2016	Q1	between groups	91,977.9	22,994.5	5.942	0.001***
		within groups	10,719,980.6	3,870.0		
	Q2	between groups	94,897.9	23,724.5	6.383	0.001***
		within groups	10,422,151.4	3,716.9		
	Q3	between groups	101,123.1	25,280.8	6.630	0.001***
		within groups	10,938,934.1	3,812.8		
	Q4	between groups	122,717.7	30,679.4	7.689	0.001***
		within groups	11,850,023.6	3,989.9		
2017	Q1	between groups	152,157.8	38,039.5	8.711	0.001***
		within groups	13,559,692.9	4,367.1		
	Q2	between groups	160,182.5	40,045.6	8.386	0.001***
		within groups	15,356,950.0	4,775.2		
	Q3	between groups	157,303.7	39,325.9	7.164	0.001***
		within groups	18,230,799.6	5,489.6		
	Q4	between groups	154,213.8	38,553.4	6.307	0.001***
		within groups	20,839,826.7	6,113.2		

2018	Q1	between groups	157,645.0	39,411.3	6.783	0.001***
		within groups	20,022,267.5	5,810.3		
	Q2	between groups	147,171.2	36,792.8	7.673	0.001***
		within groups	16,649,429.3	4,795.3		
	Q3	between groups	154,994.0	38,748.5	6.803	0.001***
		within groups	19,924,585.8	5,696.0		
	Q4	between groups	116,603.3	29,150.8	6.707	0.001***
		within groups	15,282,273.4	4,346.5		
2019	Q1	between groups	159,502.7	39,875.7	7.069	0.001***
		within groups	20,018,809.5	5,640.7		
	Q2	between groups	179,999.7	44,999.9	7.501	0.001***
		within groups	21,476,143.5	5,998.9		
	Q3	between groups	161,448.0	40,362.0	7.194	0.001***
		within groups	20,434,531.2	5,610.8		
	Q4	between groups	170,838.7	42,709.7	7.017	0.001***
		within groups	22,618,097.3	6,086.7		
2020	Q1	between groups	145,358.0	36,339.5	7.785	0.001***
		within groups	17,584,061.9	4,667.9		
	Q2	between groups	156,843.8	39,211.0	7.549	0.001***
		within groups	19,909,391.3	5,194.2		
	Q3	between groups	183,468.3	45,867.1	7.911	0.001***
		within groups	23,250,306.3	5,798.1		
	Q4	between groups	280,436.1	70,109.0	9.797	0.001***
		within groups	29,426,404.0	7,156.2		
2021	Q1	between groups	255,292.6	63,823.2	8.898	0.001***
		within groups	30,210,698.4	7,172.5		
	Q2	between groups	305,345.9	76,336.5	10.641	0.001***
		within groups	31,255,478.4	7,173.6		

p*<0.05, p**≤0.01, p***≤0.001; Data: Author's calculation

Since group #4 does not show apparently higher market capitalization mean whereas group #0 show apparently the lowest market capitalization mean in Figure 3, Table 10 further shows the multiple comparisons of ANOVA on market capitalization between group #0 and the other groups in order to find out which design grant's patent life group has higher and/or lower market capitalization.

Table 10: Multiple comparisons of ANOVA on market capitalization between design grant's patent life groups

				Market capitalization (billion RMB)		
Year	Quarter	(I) Group	(J) Group	Mean difference (I-J)	Standard error	p
2016	Q1	#0	#1	-13.912	3.890	0.001***
		#0	#2	-10.522	3.895	0.007**
		#0	#3	-10.103	3.895	0.010**
		#0	#4	-11.172	3.912	0.004**
	Q2	#0	#1	-13.090	3.762	0.001***
		#0	#2	-12.882	3.767	0.001***
		#0	#3	-8.251	3.777	0.029*
		#0	#4	-11.340	3.782	0.003**
	Q3	#0	#1	-13.220	3.757	0.001***
		#0	#2	-14.349	3.757	0.001***
		#0	#3	-8.205	3.767	0.029*
		#0	#4	-11.664	3.764	0.002**
	Q4	#0	#1	-15.372	3.764	0.001***
		#0	#2	-2.357	3.773	0.532
		#0	#3	-14.131	3.782	0.001***
		#0	#4	-11.664	3.764	0.002**
2017	Q1	#0	#1	-4.270	3.842	0.266
		#0	#2	-19.266	3.846	0.001***
		#0	#3	-9.122	3.851	0.018*
		#0	#4	-14.431	3.864	0.001***
	Q2	#0	#1	-5.987	3.937	0.128
		#0	#2	-19.797	3.937	0.001***
		#0	#3	-9.345	3.941	0.018*
		#0	#4	-13.841	3.954	0.001***
	Q3	#0	#1	-4.086	4.123	0.322
		#0	#2	-19.873	4.123	0.001***
		#0	#3	-9.318	4.132	0.024*
		#0	#4	-11.918	4.141	0.004**
	Q4	#0	#1	-5.688	4.279	0.184
		#0	#2	-16.065	4.279	0.001***
		#0	#3	-15.386	4.288	0.001***
		#0	#4	-11.576	4.301	0.007**
2018	Q1	#0	#1	-5.370	4.132	0.194
		#0	#2	-13.214	4.136	0.001***
		#0	#3	-17.708	4.144	0.001***
		#0	#4	-11.898	4.152	0.004**
	Q2	#0	#1	-4.507	3.722	0.226
		#0	#2	-9.509	3.722	0.011*
		#0	#3	-18.110	3.725	0.001***
		#0	#4	-12.045	3.739	0.001***

	Q3	#0	#1	-3.247	4.019	0.419
		#0	#2	-10.899	4.023	0.007**
		#0	#3	-17.412	4.026	0.001***
		#0	#4	-13.031	4.041	0.001***
	Q4	#0	#1	-3.072	3.489	0.379
		#0	#2	-9.850	3.489	0.005**
		#0	#3	-15.182	3.498	0.001***
		#0	#4	-10.766	3.504	0.002**
2019	Q1	#0	#1	-2.886	3.946	0.465
		#0	#2	-12.052	3.950	0.002**
		#0	#3	-17.036	3.956	0.001***
		#0	#4	-12.787	3.967	0.001***
	Q2	#0	#1	-2.746	4.033	0.496
		#0	#2	-12.549	4.033	0.002**
		#0	#3	-19.342	4.043	0.001***
		#0	#4	-10.661	4.050	0.009**
	Q3	#0	#1	-3.824	3.860	0.322
		#0	#2	-14.927	3.864	0.001***
		#0	#3	-16.382	3.870	0.001***
		#0	#4	-9.850	3.879	0.011*
	Q4	#0	#1	-7.432	3.966	0.061
		#0	#2	-10.455	3.966	0.008**
		#0	#3	-19.278	3.972	0.001***
		#0	#4	-10.610	3.984	0.008**
2020	Q1	#0	#1	-3.951	3.433	0.250
		#0	#2	-14.123	3.433	0.001***
		#0	#3	-14.986	3.441	0.001***
		#0	#4	-9.473	3.449	0.006**
	Q2	#0	#1	-14.153	3.572	0.001***
		#0	#2	-8.291	3.572	0.020*
		#0	#3	-15.152	3.580	0.001***
		#0	#4	-11.287	3.588	0.002**
	Q3	#0	#1	-14.922	3.677	0.001***
		#0	#2	-8.580	3.680	0.020*
		#0	#3	-16.397	3.685	0.001***
		#0	#4	-11.371	3.695	0.002**
	Q4	#0	#1	-13.214	4.031	0.001***
		#0	#2	-11.616	4.033	0.004**
		#0	#3	-23.052	4.039	0.001***
		#0	#4	-12.513	4.049	0.002**
2021	Q1	#0	#1	-13.922	3.977	0.001***
		#0	#2	-10.020	3.980	0.012*
		#0	#3	-19.511	3.985	0.001***
		#0	#4	-15.871	3.997	0.001***

	Q2	#0	#1	-17.568	3.901	0.001***
		#0	#2	-10.489	3.903	0.007**
		#0	#3	-21.477	3.908	0.001***
		#0	#4	-13.057	3.919	0.001***

p*<0.05, p**≤0.01, p***≤0.001; Data: Author's calculation

In Table 10, from 2016Q1 to 2016Q3, the market capitalization variances between groups #0 and any other groups are of significance. In 2016Q4, the market capitalization variances between groups #0 and #1, between groups #0 and #3, between groups #0 and #4, are of significance whereas the market capitalization variance between groups #0 and #2 is free of significance. From 2017Q1 to 2020Q1, the market capitalization variances between groups #0 and #2, between groups #0 and #3, between groups #0 and #4, are of significance whereas the market capitalization variances between groups #0 and #1 are free of significance. From 2020Q2 to 2021Q2, the market capitalization variances between groups #0 and any other groups are of significance.

According to the significant mean differences, groups #3 show the highest market capitalization means in fourteen quarters, while groups #0 show the lowest market capitalization means in all of twenty-two quarters; however, there are twelve quarters in which the market capitalization variances between groups #0 and #1 are free of significance. In summary, the A-shares without design grant patents, i.e. groups #0, usually show the lowest market capitalization means; the A-shares with design grant's patent lives slightly higher than the general level, i.e. group #3, usually show higher market capitalization means while the A-shares with the longest design grant's patent lives, i.e. group #4, does not show outstanding market capitalization means. According to China patent law, the patent term of a design grant ends ten years from the patent filing date. The patent life means of groups #3 shown in Table 8 are not longer than four years. It means that the design grants with longer patent life might appropriate to regard as the patents of higher value.

4 Conclusion and Recommendation

By setting the market capitalization as the frame of patent value reference, twenty-two quarter's market capitalization from 2016Q1 to 2021Q2 of China A-shares listed in Shanghai stock exchange and Shenzhen stock exchange were collected. All valid patent data of three patent species including the invention grant, the utility model grant and the design grant, before the end of aforementioned quarters were retrieved. With regard to each patent species, the average patent life of all valid patent of each A-share was calculated. All A-shares in each quarter were divided into four patent life groups based on their percentile rank of patent lives, wherein, group #1 had the shortest patent life mean while group #4 had the longest patent life mean. The variances of the market capitalization between different patent life groups were analyzed via ANOVA. The following conclusions were arrived:

(1) For the patent species of the invention grant, there were thirteen quarters in which the market capitalization variances between patent life groups were of significance. The rate of significance was higher than 50%. The invention grant's patent life was a significant indicator for discriminating China A-share's market capitalization before 2019Q1. The A-shares with patent lives above the general level, i.e. groups #3 and #4, usually showed higher market capitalization means than the A-shares with patent lives below the general level, i.e. groups #1 and #2. The A-shares in the longest patent life group, i.e. group #4, always showed the highest market capitalization means before 2019Q1. The invention grants with longer patent life might be regarded as the patents of higher value. However, the invention grants with longer patent life did not show significantly higher value since 2019Q2.

(2) For the patent species of the utility model grant, there were only eight quarters in which the market capitalization variances between patent life groups were of significance. The rate of significance was less than 50%. The utility model grant's patent life was not a significant indicator for discriminating China A-share's market capitalization. The utility model grants with longer patent life might not be regarded as the

patents of higher value. However, for the eight quarters of significance, the A-shares with patent lives above the general level usually showed higher market capitalization means than the A-shares with patent lives below the general level; the A-shares in the longest patent life group always showed the highest market capitalization means.

(3) For the patent species of the design grant, there were all twenty-two quarters in which the market capitalization variances between patent life groups were of significance. The rate of significance was l00%. The design grant's patent life was a significant indicator for discriminating China A-share's market capitalization. The A-shares with design grant's patent lives slightly higher than the general level, i.e. group #3, usually showed higher market capitalization means. Unlike the invention grant and the utility model grant, the A-shares with the longest design grant's patent lives, i.e. group #4, did not show higher market capitalization means. The design grants with longer patent life was not regarded as the patents of higher value. Meanwhile, the patent life means of groups #3 were close to but not longer than four years, which might be the optimal design grant's patent life.

(4) With regard to the A-shares in the shortest patent life group, i.e. group #1, of either the invention grant or the utility model grant, it was found that these A-shares showed significantly lower market capitalization mean than the A-shares without patents, i.e. group #0. In addition, with regard to the A-shares in the shortest design grant's patent life group, there were twelve quarters in which these A-shares did not showed significantly different market capitalization means from the A-shares without design patents. It implied that the patent would not contribute company's financial performance immediately. It needed time. The design grant needed shorter time whereas the invention grant needed longer time.

This research thoroughly discussed China A-share's market capitalization corresponding to patent life of different patent species. The finding would refine the company evaluation approach and reform the patent valuation criteria. The finding would help the government to make or adjust the proper patent policy and/or administration rules. For example, there was no need to set up the high value invention grant criteria of "ten years", the appropriate high value patent life could be set around 7.99 years which was the invention grant's patent life mean of group #4 in 2019Q1 as shown in Table 2. In addition, the design grant should also be taken into account as the high value patent species because the market capitalization variances between design grant's patent life groups were of significance in all quarters from 2016Q1 to 2021Q2. Based on this research, there would be an issue for any interested researchers to find out the value curve of patent life for improving patent asset management.

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