

Using Patent Forward Citation for Discriminating Stock Price in China Stock Market

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Abstract Based on the company integrated database, thousands of China listed companies of RMB common stocks (A-shares) from 2016 to 2020 were studied. The impact of the forward citation count on the stock price was thoroughly analyzed via ANOVA. The patent interval of six years showed its preferable significance for retrieving patents and calculating the forward citation count. The forward citation count was good for discriminating the stock price. However, the result did not agree previous studies because the A-shares having patents but receiving no forward citations were proved to have the highest stock price mean whereas the A-shares receiving forward citation counts above the average had the lowest stock price mean no matter before or under the impact of COVID-19. The positive effect of the forward citation on the stock price did not show. The finding would improve the understanding of China patents and the innovation outcome of China A-shares over recent years.

Keywords: China A-share, patent, ANOVA, stock price, forward citation

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1. Introduction

Innovation is an essential driver of economic progress that benefits consumers, businesses and the economy as a whole. The technological innovation is a key driver of economic growth. The stock market usually reflects the economic conditions of an economy.

China has been the largest domestic patent application country in the world for many years. China Intellectual Property Administration (CNIPA) is now the world's largest patent office. In 2020, there are more than three million of patent published and/or granted by CNIPA, including 1,517 thousand of invention publications, 530 thousand of invention grants and 2,377 thousand of utility model grants. Meanwhile, China is now the world No.2 economy to have a stock market with the world No.2 transaction volume. China listed companies lead the development of China patents, which the unlisted companies and individuals follow.

With so huge amount of China patents, CNIPA faced the challenges in trying to process more patent applications in a shorter period of time and made some achievements [1]. Based on patent information, Motohashi [2] examined China's development of innovation capabilities from 1985 to 2005 by using more than 679 thousand of China invention patent. Motohashi [3] proposed to see a substantial trend of Chinese firms catching up with Western counterparts via patent statistics

in two high-tech sectors: the pharmaceutical industry and mobile communications technology. He found that these two fields show contrasting trends, the rapid catching up can be found in mobile communications technology, while Chinese companies are still lagging behind Western counterparts in the pharmaceutical industry. Hu and Jefferson [4] used a firm-level data set that spans the population of China's large and medium-size industrial enterprises to explore the factors that account for China's rising patent activity. They found that China's patent surge is seemingly paradoxical given the country's weak record of protecting intellectual property rights. Lei, Zhao, Zhang, Chen, Huang and Zhao [5] found that the inventive activities of China have experienced three developmental phases and have been promoted quickly in recent years. The innovation strengths of the three development phases have shifted from government to university and research institute and then industry. Li [6] found that the patent subsidy programs implemented by each provincial region have played an important role in the growth of Chinese patenting. Liu and Qiu [7] used Chinese firm-level patent data from 1998 to 2007 which featured a drastic input tariff cut in 2002 because of China's WTO accession. They found that input tariff cut results in a less innovation undertaken by Chinese firms.

Boeing and Mueller [8] proposed a patent quality index based on internationally comparable citation data from international search reports (ISR) to consider foreign, domestic, and self citations. They found that all three citation types may be used as economic indicators if

policy distortion is not a concern. They also suggested that the domestic and self-citations suffer from an upward bias in China and should be employed with caution if they are to be interpreted as a measure of patent quality.

Dang and Motohashi [9] proposed that China patent statistics are meaningful indicators because China valid patent count is correlated with R&D input and financial output. Chen and Zhang [10] studied China's patent surge and its driving forces on patent applications filed by Chinese firms and found that R&D investment, foreign direct investment, and patent subsidy have different effects on different types of patents. They found that R&D investment has a positive and significant impact on patenting activities for all types of patents; the stimulating effect of foreign direct investment on patent applications is only robust for utility model patents and design patents; the patent subsidy only has a positive impact on design patents.

He, Tong, Zhang and He [11] found that it was difficult in integrating Chinese patent data with company data, so they constructed a China patent database of all China listed companies and their subsidiaries from 1990 to 2010. Chen, Wei and Che [12,13] used the patent data and stock data of China listed companies of Ren-Min-Bi common stocks (A-shares) in Shanghai main board (SH main board) from 2011 to 2017 and found the patent indicators have leading effect on A-share's stock price. Chiu, Chen and Che [14,15] focused on the whole China A-shares without distinguishing the stock boards from 2016Q4 to 2018Q3. They found that the patent indicators also have leading effect on the financial indicators including the stock price, 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). The patent prediction equations for quantitatively giving the predictive values of the aforementioned financial indicators are proposed.

The China A-shares are listed on four stock boards including SH main board, Shenzhen main board (SZ main board), Growing-Enterprises board (GE board) and Small-and-Medium Enterprises board (SME board). The

majority of A-shares in SH main board, SZ main board are state-owned companies and big companies; most A-shares in GE board and SME board are small and medium companies. Chiu, Chen and Che [16-20], Li, Deng and Che [21,22,23] further studied the patent leading effect on each stock board, 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 the performance surpassing the market trend.

COVID-19 is an impact to everything including technology and finance. The World Health Organization (WHO) on March 11, 2020, has declared COVID-19 outbreak a global pandemic. The stock markets around the world including China stock market fluctuated dramatically in 2020. Figure 1 shows the principal China stock indexes performance from Jan. 2016 to Dec. 2020, wherein, 300317 is the stock index consisting of all China A-shares, 000002 is the stock index consisting of all A-shares in Shanghai stock exchange, 399107 is the stock index consisting of all A-shares in Shenzhen stock exchange. It is interesting that the principal stock indexes in 2020 are in an up-going trend with fluctuation.

In addition, the fluctuation modes of stock indexes are far beyond any patent indicator's varying trend. Is it possible to correlate China stock market with patent? Tsai, Che and Bai [24-28] discussed the relationship between China patents and China A-shares' stock performance in 2020. It is found that the A-shares with the higher innovation continuity have the higher stock return rate mean no matter what patent species [24]; the A-shares having patents of the higher patent count show the higher stock price mean and the higher stock return rate mean [25]; the A-shares having patents of the higher technology variety show the higher stock return rate mean [26]; the A-shares having patent grants of the longer examination duration show the higher stock return rates [27]; the A-shares having higher backward citation counts show higher stock price means than the A-shares of lower backward citation counts [28].

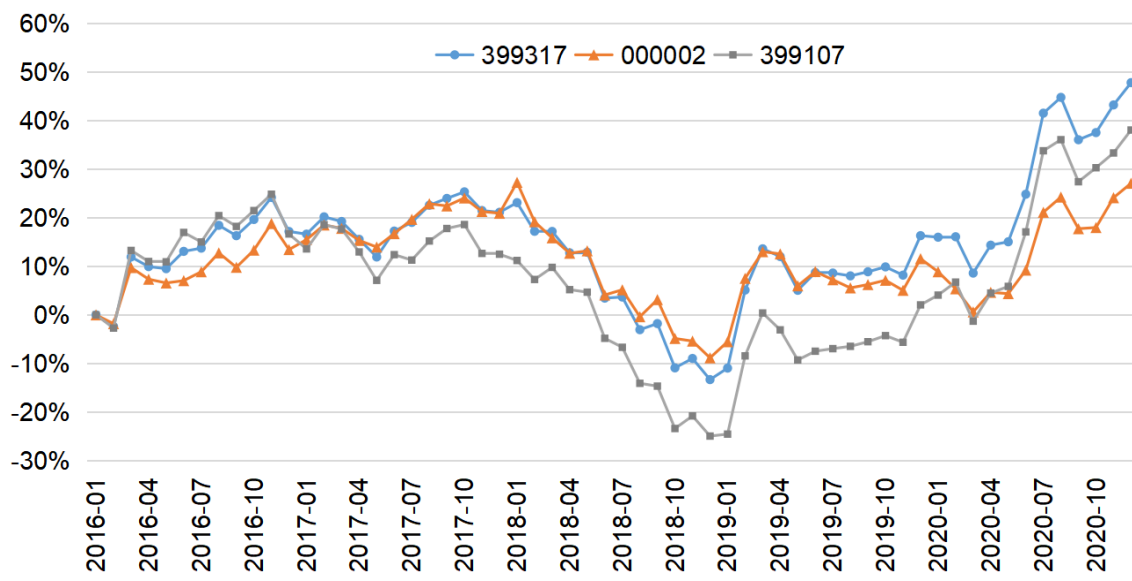


Figure 1. Performance of Principal China Stock Indexes from Jan. 2016 to Dec. 2020 (Data Source: Shanghai Stock Exchange and Shenzhen Stock Exchange)

When an earlier patent is published or granted, it could be used by the examiners as the prior art for testing the novelty and non-obviousness of the new patent application which is recognized as the forward citation of the earlier patent. The forward citation count of a patent is the frequency which the patent being applied by the examiners. A patent of high forward citation count is implied to have high influence to the technology involved and regarded of high value. Companies having more high valuable patents are usually regarded to have better financial achievement [29,30,31]. Lai and Che [32,33,34] focused on US patents and applied the forward citation count as an indicator for quantitatively modeling US patent values. Though the forward citation count of China patents has been applied for quantitatively giving the predictive values of A-share's financial indicators [12-23], however, the detailed relationship between the forward citation count and A-share's stock price is not yet discussed. It is therefore the objective of this research to find out whether the forward citation count positively relates to China A-share's stock price or not, and more particularly, to see whether the relationship is different before and under the COVID-19 pandemic.

2. Methodology

2.1. Company Integrated Patent Database

It is a common phenomenon that a listed company has lots subsidiaries. When a subsidiary's revenue is merged to its parent company as showed in the formal financial report, the subsidiary's patents are inferred to contribute to parent company's financial performance. Therefore, a company integrated patent database is built and applied in this research, wherein, all subsidiaries' patents are merged together with parent company's patents. Furthermore, if a patent is co-owned by parent company and any of the subsidiaries, it is regarded as a single 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 duplicately specified to each of the co-owners for counting.

2.2. Patent Forward Citation

There are four major patent species in China including the invention publication, the invention grant, the utility model grant and the design grant. The design grant is a design application of a product which granted by overcoming the preliminary examination by having a distinct configuration, distinct surface ornamentation or both. The utility model grant is a utility model application of a product which granted by overcoming the preliminary examination. The invention publication is an invention application of a product or a process which published by overcoming the preliminary examination. The invention grant is an invention application which granted by overcoming not only the preliminary examination but also

the substantial examination by having novel and distinct technical features over the prior arts, especially the prior patents. In this research, the forward citation of four patent species are all considered.

A patent with more forward citations implies to have a higher influence to the technology involved. A company having patents with lots of forward citations usually implies to have good R&D capability and innovation outcome. Such companies seem to have better financial achievement. In this research, the forward citation count of an A-share is therefore defined as the summation of total forward citation counts of all patents of the A-share no matter what patent species is.

In order to derive the proper forward citation counts of all A-shares, the patent interval for retrieving patents is another important issue. Thomas [29] proposed a "current impact index" which is the total forward citation count calculated over the previous one year and the patents being cited are retrieved by the patent grant day from previous two to six years. In this research, six patent intervals from one year to six years are proposed and compared by considering the concept of the current impact index. For patent interval of one year, the total forward citation count is calculated over the previous one year and the patents being cited are retrieved by the patent publication/grant date over previous one year; for patent interval of two years, the total forward citation count is calculated over the previous two years and the patents being cited are retrieved by the patent publication/grant date over previous two years; and so forth the patent intervals of three, four, five and six years.

The Kolmogorov-Smirnov test is applied on the forward citation count of various patent intervals. The test result shows that the original data distributions of forward citation counts are seriously skewed. Therefore, all forward citation counts in this research are transformed by natural logarithm before any analysis.

2.3. Population and Sample

The quarter based analysis is applied on the twenty quarters from 2016 to 2020 in this research for avoiding bias. The population comprises all China companies listed in Shanghai exchange and Shenzhen exchange from 2016 to 2020, whereas China companies listed in Hong Kong or any other overseas countries are excluded. An effective sample of A-share for any quarter must meet the following conditions:

- (1) It was listed to have a definite stock closing price in the last trading day of said quarter; and
- (2) It must have at least one new patent published or granted for calculating forward citation count during the specified patent interval as described in sub-section 2.2.

Table 1 shows the effective samples statistics by quarter from 2016 to 2020. Based on the world's No. 2 stock transaction volume of China, the number of effective samples in each quarter is around 2,000. The sampling rate for effective samples ranges from 50.8% to 64.1%. The analysis in this research should be free of survivorship bias.

Table 1. Effective Samples Statistics in Every Quarter from 2016 to 2020

Year	Quarter	Number of A-shares in Patent Interval					
		1	2	3	4	5	6
2016	Q1	2,315	2,399	2,444	2,471	2,495	2,510
	Q2	2,368	2,446	2,490	2,516	2,537	2,553
	Q3	2,408	2,503	2,552	2,577	2,593	2,610
	Q4	2,424	2,564	2,611	2,640	2,661	2,674
2017	Q1	2,495	2,651	2,691	2,726	2,748	2,762
	Q2	2,540	2,743	2,781	2,813	2,836	2,850
	Q3	2,560	2,755	2,809	2,841	2,862	2,873
	Q4	2,735	2,876	2,942	2,972	2,989	3,005
2018	Q1	2,772	2,955	3,023	3,038	3,058	3,065
	Q2	2,805	2,945	3,050	3,062	3,076	3,088
	Q3	2,834	2,949	3,045	3,073	3,086	3,098
	Q4	2,853	2,961	3,055	3,089	3,103	3,115
2019	Q1	2,897	2,991	3,082	3,130	3,141	3,153
	Q2	2,927	3,039	3,099	3,173	3,183	3,194
	Q3	3,016	3,141	3,194	3,263	3,285	3,297
	Q4	3,036	3,164	3,215	3,280	3,305	3,313
2020	Q1	3,024	3,158	3,216	3,280	3,315	3,321
	Q2	3,049	3,161	3,226	3,262	3,319	3,327
	Q3	3,033	3,159	3,227	3,260	3,315	3,328
	Q4	3,048	3,162	3,228	3,264	3,310	3,326

Data Source: This Research.

All effective sample A-shares are further divided into three citation groups for testing the stock return rate variance. The definitions of three citation groups are shown below.

N-group: A-shares have patents but without any forward citations.

B-group: A-shares have patents and the resulting forward citation counts below the average of all A-shares in the specific quarter;

A-group: A-shares having patents and the resulting forward citation counts above the average of all A-shares in the specific quarter.

2.4. Analysis of Variance

Analysis of Variance (ANOVA) is applied in this research for discovering:

(1) Whether the stock price means between different citation groups are significantly different or not?

(2) Which citation group has significantly higher stock price means and which citation group has significantly lower stock price means?

ANOVA is a statistical approach used to compare variances across the means of different data groups. The outcome of ANOVA is the "F-Ratio".

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

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 $H_0: \mu_1 = \mu_2 = \dots = \mu_k$ 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 should be smaller than 0.05.

3. Result and Finding

3.1. Forward Citation Count

As the length of the patent interval increases, the number of the retrieved patents and the forward citation count are supposed to increase correspondingly. Table 2 to Table 5 prove it. Based on quarterly perspective, Table 2 shows the results of ANOVA on forward citation count between six patent intervals, wherein, the forward citation count variance is significant between six patent intervals in each quarter. Table 3 further shows the multiple comparisons of ANOVA on forward citation count between every two adjacent patent intervals in each quarter, wherein, the forward citation count mean significantly increases as the length of the patent interval increases.

Table 2. Result of ANOVA on Forward Citation Count between Different Patent Intervals (1)

Quarter	Patent Interval	Forward Citation Count			
		Sum Square	Mean Square	F	p
Q1	Between P.I.	14,762.2	2,952.4	1,361.9	0.001***
	Within P.I.	117,259.1	2.2		
Q2	Between P.I.	14,586.9	2,917.4	1,369.4	0.001***
	Within P.I.	111,777.7	2.1		
Q3	Between P.I.	13,758.4	2,751.7	1,317.8	0.001***
	Within P.I.	121,673.2	2.1		
Q4	Between P.I.	13,491.2	2,698.2	1,340.1	0.001***
	Within P.I.	114,403.9	2.0		

p* < 0.05, p** < 0.01, p*** < 0.001; Data Source: This Research; P.I.: Patent Interval(s)

Table 3. Multiple Comparisons of ANOVA on Forward Citation Count between Different Patent Intervals (1)

Quarter	Interval (X)	Interval (Y)	Forward Citation Count		
			Mean Diff. (X-Y)	Std. Error	p
Q1	2	1	0.369	0.031	0.001***
	3	2	0.325	0.024	0.001***
	4	3	0.352	0.021	0.001***
	5	4	0.360	0.020	0.001***
	6	5	0.292	0.019	0.001***
Q2	2	1	0.328	0.033	0.001***
	3	2	0.324	0.024	0.001***
	4	3	0.378	0.021	0.001***
	5	4	0.371	0.020	0.001***
	6	5	0.316	0.019	0.001***
Q3	2	1	0.297	0.036	0.001***
	3	2	0.327	0.025	0.001***
	4	3	0.524	0.019	0.001***
	5	4	0.224	0.017	0.001***
	6	5	0.327	0.019	0.001***
Q4	2	1	0.342	0.038	0.001***
	3	2	0.350	0.025	0.001***
	4	3	0.510	0.019	0.001***
	5	4	0.241	0.017	0.001***
	6	5	0.335	0.018	0.001***

p* < 0.05, p** < 0.01, p*** < 0.001; Data Source: This Research.

Based on yearly perspective, Table 4 shows the results of ANOVA on forward citation count between six patent intervals, wherein, the forward citation count variance between

six patent intervals is significant in every year from 2016 to 2020. Table 5 further shows the multiple comparisons of ANOVA on forward citation count between every two adjacent patent intervals in every year, wherein, the forward citation count mean significantly increases as the length of the patent interval increases. However, in 2019 and 2020, the forward citation count variance between patent intervals 1 and 2 is free of significance though patent interval 2 seem to have higher forward citation count.

Table 4. Result of ANOVA on Forward Citation Count between Different Patent Intervals (2)

Year	Patent Interval	Forward Citation Count			
		Sum Square	Mean Square	F	p
2016	Between P.I.	24,935.5	4,987.1	2,382.7	0.001***
	Within P.I.	117,410.9	2.1		
2017	Between P.I.	23,203.9	4,640.8	2,403.4	0.001***
	Within P.I.	97,170.8	1.9		
2018	Between P.I.	17,800.4	3,560.1	2,087.7	0.001***
	Within P.I.	82,396.6	1.7		
2019	Between P.I.	10,590.8	2,118.2	1,379.6	0.001***
	Within P.I.	53,921.5	1.5		
2020	Between P.I.	6,645.0	1,329.0	953.5	0.001***
	Within P.I.	44,304.5	1.4		

p* $<$ 0.05, p** \leq 0.01, p*** \leq 0.001; Data Source: This Research; P.I.: Patent Interval(s)

Table 5. Multiple Comparisons of ANOVA on Forward Citation Count between Different Patent Intervals (2)

Year	Interval (X)	Interval (Y)	Forward Citation Count		
			Mean Diff. (X-Y)	Std. Error	p
2016	2	1	0.600	0.025	0.001***
	3	2	0.480	0.022	0.001***
	4	3	0.448	0.020	0.001***
	5	4	0.361	0.019	0.001***
	6	5	0.237	0.021	0.001***
2017	2	1	0.660	0.035	0.001***
	3	2	0.575	0.023	0.001***
	4	3	0.426	0.019	0.001***
	5	4	0.516	0.018	0.001***
	6	5	0.311	0.020	0.001***
2018	2	1	0.372	0.036	0.001***
	3	2	0.571	0.023	0.001***
	4	3	0.440	0.019	0.001***
	5	4	0.402	0.017	0.001***
	6	5	0.369	0.018	0.001***
2019	2	1	0.116	0.067	0.083
	3	2	0.320	0.032	0.001***
	4	3	0.539	0.022	0.001***
	5	4	0.455	0.019	0.001***
	6	5	0.365	0.018	0.001***
2020	2	1	0.176	0.074	0.018
	3	2	0.148	0.033	0.001***
	4	3	0.282	0.023	0.001***
	5	4	0.467	0.019	0.001***
	6	5	0.400	0.017	0.001***

p* $<$ 0.05, p** \leq 0.01, p*** \leq 0.001; Data Source: This Research.

3.2. Stock Price Variance

The Kolmogorov-Smirnov test is also applied on the stock price. The test result shows that the original data

distributions of the stock price in the currency of RMB are seriously skewed. Therefore, all stock prices discussed in this research had been also transformed by natural logarithm.

In order to confirm whether the stock price means between citation groups are significantly different or not, Table 6 to Table 11 show the results of ANOVA on the stock price between different citation groups according to patent intervals of one year to six years. For patent interval of one year as shown in Table 6, the stock price variances between citation groups are of significance in all quarters of 2016 and 2017, two quarters of 2018, and one quarter of 2020; whereas the stock price variances between citation groups are free of significance in any quarter from 2018 to 2020. In all twenty quarters from 2016 to 2020, there are eleven quarters in which the stock price variances between citation groups are of significance.

Table 6. ANOVA on Stock Price between Citation Groups with Regard to Patent Interval=1

Year	Quarter	Citation Group	Stock Price			
			Sum Square	Mean Square	F	p
2016	Q1	Between C.G.	11.5	5.7	13.3	0.001***
		Within C.G.	998.9	0.4		
	Q2	Between C.G.	9.6	4.8	11.1	0.001***
		Within C.G.	1,025.0	0.4		
	Q3	Between C.G.	11.1	5.6	13.8	0.001***
		Within C.G.	971.1	0.4		
	Q4	Between C.G.	11.2	5.6	13.3	0.001***
		Within C.G.	1,022.2	0.4		
2017	Q1	Between C.G.	13.7	6.8	15.9	0.001***
		Within C.G.	1,075.2	0.4		
	Q2	Between C.G.	6.2	3.1	7.6	0.001***
		Within C.G.	1,023.1	0.4		
	Q3	Between C.G.	8.3	4.2	10.5	0.001***
		Within C.G.	1,013.3	0.4		
	Q4	Between C.G.	7.9	4.0	8.8	0.001***
		Within C.G.	1,237.0	0.5		
2018	Q1	Between C.G.	6.0	3.0	7.6	0.001***
		Within C.G.	1,089.2	0.4		
	Q2	Between C.G.	3.0	1.5	3.4	0.034*
		Within C.G.	1,242.9	0.4		
	Q3	Between C.G.	0.0	0.0	0.0	0.976
		Within C.G.	1,133.3	0.4		
	Q4	Between C.G.	0.3	0.1	0.4	0.700
		Within C.G.	1,121.1	0.4		
2019	Q1	Between C.G.	0.2	0.1	0.3	0.746
		Within C.G.	1,217.4	0.4		
	Q2	Between C.G.	0.1	0.0	0.1	0.936
		Within C.G.	1,378.7	0.5		
	Q3	Between C.G.	0.0	0.0	0.0	0.990
		Within C.G.	1,710.9	0.6		
	Q4	Between C.G.	0.6	0.3	0.5	0.610
		Within C.G.	1,789.6	0.6		
2020	Q1	Between C.G.	0.8	0.4	0.6	0.551
		Within C.G.	1,934.4	0.6		
	Q2	Between C.G.	3.9	2.0	2.6	0.073
		Within C.G.	2,285.5	0.8		
	Q3	Between C.G.	3.4	1.7	2.3	0.099
		Within C.G.	2,203.8	0.7		
	Q4	Between C.G.	9.5	4.7	6.2	0.002**
		Within C.G.	2,308.4	0.8		

p* $<$ 0.05, p** \leq 0.01, p*** \leq 0.001; Data Source: This Research; C.G.: Citation Group(s)

For patent interval of two years as shown in Table 7, the stock price variances between citation groups are of significance in all quarters from 2016 to 2018, and two quarters in 2020; whereas the stock price variances between citation groups in any other quarters are free of significance. In all twenty quarters from 2016 to 2020, there are fourteen quarters in which the stock price variances between citation groups are of significance.

Table 7. ANOVA on Stock Price between Citation Groups with Regard to Patent Interval=2

Year	Quarter	Citation Group	Stock Price			
			Sum Square	Mean Square	F	p
2016	Q1	Between C.G.	7.2	3.6	8.3	0.001***
		Within C.G.	1,032.2	0.4		
	Q2	Between C.G.	5.5	2.8	6.4	0.002**
		Within C.G.	1,065.6	0.4		
	Q3	Between C.G.	7.0	3.5	8.6	0.001***
		Within C.G.	1,022.7	0.4		
	Q4	Between C.G.	14.6	7.3	17.1	0.001***
		Within C.G.	1,089.0	0.4		
2017	Q1	Between C.G.	16.9	8.5	19.8	0.001***
		Within C.G.	1,131.3	0.4		
	Q2	Between C.G.	21.1	10.5	26.7	0.001***
		Within C.G.	1,080.7	0.4		
	Q3	Between C.G.	17.6	8.8	22.6	0.001***
		Within C.G.	1,073.4	0.4		
	Q4	Between C.G.	31.9	16.0	36.1	0.001***
		Within C.G.	1,268.5	0.4		
2018	Q1	Between C.G.	12.5	6.2	15.9	0.001***
		Within C.G.	1,155.4	0.4		
	Q2	Between C.G.	6.9	3.5	7.8	0.001***
		Within C.G.	1,298.2	0.4		
	Q3	Between C.G.	5.8	2.9	7.3	0.001***
		Within C.G.	1,165.6	0.4		
	Q4	Between C.G.	6.8	3.4	8.8	0.001***
		Within C.G.	1,144.1	0.4		
2019	Q1	Between C.G.	2.4	1.2	2.9	0.055
		Within C.G.	1,249.9	0.4		
	Q2	Between C.G.	1.6	0.8	1.7	0.182
		Within C.G.	1,419.9	0.5		
	Q3	Between C.G.	1.4	0.7	1.3	0.282
		Within C.G.	1,777.4	0.6		
	Q4	Between C.G.	0.4	0.2	0.3	0.731
		Within C.G.	1,869.9	0.6		
2020	Q1	Between C.G.	0.6	0.3	0.5	0.604
		Within C.G.	2,025.4	0.6		
	Q2	Between C.G.	1.4	0.7	0.9	0.397
		Within C.G.	2,362.9	0.7		
	Q3	Between C.G.	5.3	2.6	3.6	0.026*
		Within C.G.	2,283.7	0.7		
	Q4	Between C.G.	11.8	5.9	7.8	0.001***
		Within C.G.	2,378.6	0.8		

p* <0.05 , p** ≤ 0.01 , p*** ≤ 0.001 ; Data Source: This Research; C.G.: Citation Group(s)

For patent interval of three years as shown in Table 8, the stock price variances between citation groups are of significance in all quarters from 2016 to 2019, and one quarter of 2020; whereas the stock price variances

between citation groups in any other quarters are free of significance. In all twenty quarters from 2016 to 2020, there are seventeen quarters in which the stock price variances between citation groups are of significance.

Table 8. ANOVA on Stock Price between Citation Groups with Regard to Patent Interval=3

Year	Quarter	Quarter	Stock Price			
			Sum Square	Mean Square	F	p
2016	Q1	Between C.G.	6.5	3.2	7.4	0.001***
		Within C.G.	1,058.6	0.4		
	Q2	Between C.G.	3.5	1.8	4.0	0.018*
		Within C.G.	1,087.6	0.4		
	Q3	Between C.G.	6.6	3.3	8.0	0.001***
		Within C.G.	1,042.2	0.4		
	Q4	Between C.G.	13.3	6.7	15.7	0.001***
		Within C.G.	1,107.7	0.4		
2017	Q1	Between C.G.	22.1	11.1	26.0	0.001***
		Within C.G.	1,143.9	0.4		
	Q2	Between C.G.	25.2	12.6	31.8	0.001***
		Within C.G.	1,099.2	0.4		
	Q3	Between C.G.	22.3	11.2	28.6	0.001***
		Within C.G.	1,093.6	0.4		
	Q4	Between C.G.	50.6	25.3	58.4	0.001***
		Within C.G.	1,274.8	0.4		
2018	Q1	Between C.G.	18.6	9.3	24.0	0.001***
		Within C.G.	1,169.4	0.4		
	Q2	Between C.G.	28.7	14.4	33.2	0.001***
		Within C.G.	1,317.1	0.4		
	Q3	Between C.G.	17.9	9.0	22.9	0.001***
		Within C.G.	1,188.6	0.4		
	Q4	Between C.G.	15.5	7.7	20.2	0.001***
		Within C.G.	1,170.6	0.4		
2019	Q1	Between C.G.	10.1	5.1	12.2	0.001***
		Within C.G.	1,275.9	0.4		
	Q2	Between C.G.	6.5	3.2	6.9	0.001***
		Within C.G.	1,440.2	0.5		
	Q3	Between C.G.	14.3	7.1	12.7	0.001***
		Within C.G.	1,788.4	0.6		
	Q4	Between C.G.	8.0	4.0	6.8	0.001***
		Within C.G.	1,882.5	0.6		
2020	Q1	Between C.G.	6.0	3.0	4.7	0.009**
		Within C.G.	2,051.0	0.6		
	Q2	Between C.G.	4.0	2.0	2.7	0.071
		Within C.G.	2,407.0	0.7		
	Q3	Between C.G.	1.8	0.9	1.3	0.284
		Within C.G.	2,329.7	0.7		
	Q4	Between C.G.	4.4	2.2	2.9	0.056
		Within C.G.	2,434.6	0.8		

p* <0.05 , p** ≤ 0.01 , p*** ≤ 0.001 ; Data Source: This Research; C.G.: Citation Group(s)

For patent interval of four years as shown in Table 9, the stock price variances between citation groups are of significance in all quarters from 2016 to 2019, and two quarters of 2020; whereas the stock price variances between citation groups in any other quarters are free of significance. In all twenty quarters from 2016 to 2020, there are eighteen quarters in which the stock price variances between citation groups are of significance.

Table 9. ANOVA on Stock Price between Citation Groups with Regard to Patent Interval=4

Year	Quarter	Citation Group	Stock Price			
			Sum Square	Mean Square	F	p
2016	Q1	Between C.G.	4.7	2.4	5.4	0.004**
		Within C.G.	1,077.5	0.4		
	Q2	Between C.G.	3.7	1.9	4.2	0.015*
		Within C.G.	1,098.9	0.4		
	Q3	Between C.G.	5.5	2.8	6.7	0.001***
		Within C.G.	1,055.6	0.4		
	Q4	Between C.G.	11.8	5.9	13.7	0.001***
		Within C.G.	1,133.2	0.4		
2017	Q1	Between C.G.	25.2	12.6	29.5	0.001***
		Within C.G.	1,161.9	0.4		
	Q2	Between C.G.	30.6	15.3	38.8	0.001***
		Within C.G.	1,107.2	0.4		
	Q3	Between C.G.	29.9	15.0	38.7	0.001***
		Within C.G.	1,097.6	0.4		
	Q4	Between C.G.	72.8	36.4	85.4	0.001***
		Within C.G.	1,266.2	0.4		
2018	Q1	Between C.G.	26.7	13.4	34.7	0.001***
		Within C.G.	1,167.8	0.4		
	Q2	Between C.G.	32.0	16.0	37.1	0.001***
		Within C.G.	1,321.7	0.4		
	Q3	Between C.G.	21.8	10.9	26.6	0.001***
		Within C.G.	1,623.0	0.4		
	Q4	Between C.G.	22.5	11.2	29.5	0.001***
		Within C.G.	1,175.0	0.4		
2019	Q1	Between C.G.	16.4	8.2	19.9	0.001***
		Within C.G.	1,288.9	0.4		
	Q2	Between C.G.	22.8	11.4	24.8	0.001***
		Within C.G.	1,454.4	0.5		
	Q3	Between C.G.	35.5	17.8	32.2	0.001***
		Within C.G.	1,799.3	0.6		
	Q4	Between C.G.	27.4	13.7	23.7	0.001***
		Within C.G.	1,894.7	0.6		
2020	Q1	Between C.G.	22.1	11.1	17.5	0.001***
		Within C.G.	2,065.7	0.6		
	Q2	Between C.G.	6.2	3.1	4.2	0.015*
		Within C.G.	2,426.2	0.7		
	Q3	Between C.G.	1.4	0.7	1.0	0.386
		Within C.G.	2,351.1	0.7		
	Q4	Between C.G.	1.1	0.6	0.7	0.480
		Within C.G.	2,459.3	0.8		

p* <0.05 , p** ≤ 0.01 , p*** ≤ 0.001 ; Data Source: This Research; C.G.: Citation Group(s)

For patent interval of five years as shown in Table 10, the stock price variances between citation groups are of significance in three quarters of 2016, all quarters from 2017 to 2019, and three quarters of 2020; whereas the stock price variances between citation groups in any other quarters are free of significance. In all twenty quarters from 2016 to 2020, there are eighteen quarters in which the stock price variances between citation groups are of significance.

Table 10. ANOVA on Stock Price between Citation Groups with Regard to Patent Interval=5

Year	Quarter	Citation Group	Stock Price			
			Sum Square	Mean Square	F	p
2016	Q1	Between C.G.	3.9	2.0	4.5	0.011*
		Within C.G.	1,088.2	0.4		
	Q2	Between C.G.	2.0	1.0	2.2	0.106
		Within C.G.	1,107.3	0.4		
	Q3	Between C.G.	4.6	2.3	5.6	0.004**
		Within C.G.	1,061.3	0.4		
	Q4	Between C.G.	12.7	6.4	14.9	0.001***
		Within C.G.	1,137.6	0.4		
2017	Q1	Between C.G.	24.4	12.2	28.5	0.001***
		Within C.G.	1,173.2	0.4		
	Q2	Between C.G.	35.8	17.9	45.6	0.001***
		Within C.G.	1,112.0	0.4		
	Q3	Between C.G.	32.9	16.4	42.6	0.001***
		Within C.G.	1,104.0	0.4		
	Q4	Between C.G.	84.7	42.4	99.8	0.001***
		Within C.G.	1,267.3	0.4		
2018	Q1	Between C.G.	31.2	15.6	40.7	0.001***
		Within C.G.	1,169.1	0.4		
	Q2	Between C.G.	39.3	19.6	45.7	0.001***
		Within C.G.	1,319.8	0.4		
	Q3	Between C.G.	25.4	12.7	32.6	0.001***
		Within C.G.	1,199.5	0.4		
	Q4	Between C.G.	29.4	14.7	38.7	0.001***
		Within C.G.	1,175.1	0.4		
2019	Q1	Between C.G.	22.0	11.0	26.7	0.001***
		Within C.G.	1,290.1	0.4		
	Q2	Between C.G.	25.8	12.9	28.1	0.001***
		Within C.G.	1,460.2	0.5		
	Q3	Between C.G.	50.8	25.4	46.3	0.001***
		Within C.G.	1,797.8	0.5		
	Q4	Between C.G.	44.8	22.4	39.1	0.001***
		Within C.G.	1,890.3	0.6		
2020	Q1	Between C.G.	42.1	21.0	33.8	0.001***
		Within C.G.	2,063.7	0.6		
	Q2	Between C.G.	36.6	18.3	25.0	0.001***
		Within C.G.	2,429.7	0.7		
	Q3	Between C.G.	11.2	5.6	7.8	0.001***
		Within C.G.	2,382.9	0.7		
	Q4	Between C.G.	1.2	0.6	0.8	0.441
		Within C.G.	2,498.3	0.8		

p* <0.05 , p** ≤ 0.01 , p*** ≤ 0.001 ; Data Source: This Research; C.G.: Citation Group(s)

For patent interval of six years as shown in Table 11, the stock price variances between citation groups are of significance in all twenty quarters from 2016 to 2020. Different citation groups have significantly different stock price means in every quarter from 2016 to 2020 according to patent interval of six years.

There are six various patent intervals applied for testing the stock price variance between citation groups. It shows that as the length of the patent interval increase, the

number of quarters in which the stock price variance being of significance increases. The patent interval of six years is therefore preferable because the stock price variances between citation groups are of significance in all quarters from 2016 to 2020.

Table 11. ANOVA on Stock Price between Citation Groups with Regard to Patent Interval=6

Year	Quarter	Citation Group	Stock Price			
			Sum Square	Mean Square	F	p
2016	Q1	Between C.G.	4.6	2.3	5.3	0.005**
		Within C.G.	1,091.6	0.4		
	Q2	Between C.G.	3.3	1.6	3.8	0.023*
		Within C.G.	1,114.6	0.4		
	Q3	Between C.G.	3.5	1.8	4.3	0.014*
		Within C.G.	1,072.7	0.4		
	Q4	Between C.G.	11.0	5.5	12.8	0.001***
		Within C.G.	1,147.2	0.4		
2017	Q1	Between C.G.	29.0	14.5	34.0	0.001***
		Within C.G.	1,177.0	0.4		
	Q2	Between C.G.	42.2	21.1	54.1	0.001***
		Within C.G.	1,110.5	0.4		
	Q3	Between C.G.	41.5	20.7	54.3	0.001***
		Within C.G.	1,096.9	0.4		
	Q4	Between C.G.	94.6	47.3	112.8	0.001***
		Within C.G.	1,258.7	0.4		
2018	Q1	Between C.G.	30.4	15.2	39.7	0.001***
		Within C.G.	1,171.6	0.4		
	Q2	Between C.G.	42.7	21.3	49.8	0.001***
		Within C.G.	1,321.2	0.4		
	Q3	Between C.G.	26.6	13.3	34.1	0.001***
		Within C.G.	1,203.8	0.4		
	Q4	Between C.G.	31.9	15.9	42.1	0.001***
		Within C.G.	1,178.5	0.4		
2019	Q1	Between C.G.	28.0	14.0	34.2	0.001***
		Within C.G.	1,289.8	0.4		
	Q2	Between C.G.	31.2	15.6	34.1	0.001***
		Within C.G.	1,458.8	0.5		
	Q3	Between C.G.	63.3	31.6	58.2	0.001***
		Within C.G.	1,791.3	0.5		
	Q4	Between C.G.	59.6	29.8	52.4	0.001***
		Within C.G.	1,883.5	0.6		
2020	Q1	Between C.G.	51.7	25.8	41.6	0.001***
		Within C.G.	2,060.4	0.6		
	Q2	Between C.G.	51.7	25.8	35.4	0.001***
		Within C.G.	2,424.9	0.7		
	Q3	Between C.G.	26.2	13.1	18.3	0.001***
		Within C.G.	2,383.4	0.7		
	Q4	Between C.G.	10.8	5.4	7.2	0.001***
		Within C.G.	2,503.7	0.8		

p* <0.05 , p** ≤ 0.01 , p*** ≤ 0.001 ; Data Source: This Research; C.G.: Citation Group(s)

Table 12 shows the statistics of the stock price of all citation groups in all quarters from 2016 to 2020 based on patent interval of six years. It is very interesting that N-groups seem to have higher stock price means than B-groups and A-group in most quarters; while A-groups seem to have lower stock price means than B-groups and N-group in most quarters.

Table 12. Stock Price Statistics of Citation Groups from 2016 to 2020 Based on Patent Interval=6

Year	Quarter	Citation Group	Stock Price				
			Mean	Std. Deviation	Min.	Max.	
2016	Q1	N-Group	2.838	0.668	1.401	4.516	
		B-Group	2.896	0.678	1.054	5.516	
		A-Group	2.808	0.642	1.201	5.268	
	Q2	N-Group	2.741	0.650	1.215	4.518	
		B-Group	2.833	0.685	1.054	5.680	
		A-Group	2.764	0.639	1.197	5.023	
	Q3	N-Group	2.831	0.694	1.281	4.934	
		B-Group	2.843	0.655	1.054	5.700	
		A-Group	2.768	0.620	1.194	5.187	
	Q4	N-Group	2.883	0.704	1.292	4.973	
		B-Group	2.907	0.687	1.054	5.815	
		A-Group	2.776	0.615	1.200	5.187	
	2017	Q1	N-Group	3.107	0.800	1.298	5.806
			B-Group	2.879	0.671	1.054	5.959
			A-Group	2.759	0.599	1.179	5.352
		Q2	N-Group	3.012	0.725	1.054	5.720
B-Group			2.696	0.637	1.054	6.144	
A-Group			2.622	0.581	0.880	4.618	
Q3		N-Group	3.028	0.710	1.078	5.394	
		B-Group	2.707	0.622	1.054	6.251	
		A-Group	2.659	0.583	0.908	4.877	
Q4		N-Group	3.048	0.747	1.078	5.467	
		B-Group	2.594	0.632	1.054	6.549	
		A-Group	2.573	0.616	0.766	5.101	
2018		Q1	N-Group	2.754	0.644	1.194	5.057
			B-Group	2.516	0.617	1.054	6.500
			A-Group	2.466	0.610	0.863	5.212
		Q2	N-Group	2.627	0.688	0.990	4.693
	B-Group		2.365	0.653	0.896	6.582	
	A-Group		2.293	0.641	0.742	5.430	
	Q3	N-Group	2.479	0.628	0.982	4.508	
		B-Group	2.263	0.619	0.571	4.833	
		A-Group	2.225	0.627	0.751	6.580	
	Q4	N-Group	2.393	0.627	0.798	4.227	
		B-Group	2.190	0.619	0.571	6.367	
		A-Group	2.113	0.606	0.747	5.168	
	2019	Q1	N-Group	2.623	0.657	0.850	4.614
			B-Group	2.428	0.636	0.571	6.736
			A-Group	2.365	0.636	0.793	5.759
		Q2	N-Group	2.559	0.710	0.571	4.700
B-Group			2.358	0.670	0.668	6.893	
A-Group			2.295	0.662	0.718	5.826	
Q3		N-Group	2.622	0.797	0.668	5.930	
		B-Group	2.349	0.731	0.438	7.048	
		A-Group	2.267	0.701	0.742	5.980	
Q4		N-Group	2.645	0.804	0.571	6.020	
		B-Group	2.382	0.740	0.713	7.077	
		A-Group	2.307	0.731	0.718	6.105	
2020		Q1	N-Group	2.581	0.851	0.571	6.057
			B-Group	2.333	0.766	0.542	7.014
			A-Group	2.274	0.760	0.647	6.308
		Q2	N-Group	2.631	0.912	0.285	6.008
	B-Group		2.401	0.840	0.157	7.289	
	A-Group		2.317	0.821	0.174	5.468	
	Q3	N-Group	2.639	0.884	0.571	5.937	
		B-Group	2.483	0.841	0.723	7.420	
		A-Group	2.410	0.824	0.308	5.578	
	Q4	N-Group	2.578	0.880	0.406	6.519	
		B-Group	2.472	0.858	0.599	7.600	
		A-Group	2.431	0.870	0.554	6.109	

Data Source: This Research.

Table 13. Multiple Comparisons of ANOVA on Stock Price between Citation Groups Based on Patent Interval=6

Year	Quarter	Group (X)	Group (Y)	Stock Price		
				Mean Diff. (X-Y)	Std. Error	p
2016	Q1	N	B	-0.058	0.059	0.321
		B	A	0.088	0.027	0.001***
		A	N	-0.030	0.058	0.607
	Q2	N	B	-0.092	0.057	0.105
		B	A	0.069	0.027	0.011*
		A	N	0.023	0.056	0.687
	Q3	N	B	-0.012	0.052	0.825
		B	A	0.075	0.026	0.004**
		A	N	-0.064	0.052	0.221
	Q4	N	B	-0.024	0.052	0.642
		B	A	0.131	0.026	0.001***
		A	N	-0.107	0.052	0.041*
2017	Q1	N	B	0.228	0.044	0.001***
		B	A	0.121	0.026	0.001***
		A	N	-0.349	0.044	0.001***
	Q2	N	B	0.316	0.038	0.001***
		B	A	0.074	0.025	0.003**
		A	N	-0.390	0.038	0.001***
	Q3	N	B	0.322	0.036	0.001***
		B	A	0.047	0.025	0.056
		A	N	-0.369	0.036	0.001***
	Q4	N	B	0.454	0.034	0.001***
		B	A	0.021	0.026	0.418
		A	N	-0.475	0.034	0.001***
2018	Q1	N	B	0.238	0.033	0.001***
		B	A	0.050	0.024	0.041*
		A	N	-0.288	0.033	0.001***
	Q2	N	B	0.262	0.034	0.001***
		B	A	0.072	0.026	0.005**
		A	N	-0.334	0.034	0.001***
	Q3	N	B	0.216	0.031	0.001***
		B	A	0.038	0.025	0.122
		A	N	-0.254	0.032	0.001***
	Q4	N	B	0.203	0.030	0.001***
		B	A	0.076	0.025	0.002**
		A	N	-0.280	0.031	0.001***
2019	Q1	N	B	0.195	0.031	0.001***
		B	A	0.062	0.026	0.015*
		A	N	-0.257	0.031	0.001***
	Q2	N	B	0.202	0.032	0.001***
		B	A	0.063	0.027	0.020*
		A	N	-0.265	0.033	0.001***
	Q3	N	B	0.273	0.033	0.001***
		B	A	0.082	0.030	0.006**
		A	N	-0.355	0.034	0.001***
	Q4	N	B	0.263	0.033	0.001***
		B	A	0.075	0.031	0.014*
		A	N	-0.339	0.034	0.001***
2020	Q1	N	B	0.247	0.034	0.001***
		B	A	0.060	0.032	0.063
		A	N	-0.307	0.035	0.001***
	Q2	N	B	0.230	0.037	0.001***
		B	A	0.084	0.035	0.016*
		A	N	-0.314	0.038	0.001***
	Q3	N	B	0.156	0.037	0.001***
		B	A	0.073	0.034	0.032*
		A	N	-0.230	0.038	0.001***
	Q4	N	B	0.106	0.038	0.006*
		B	A	0.041	0.035	0.238
		A	N	-0.147	0.039	0.001***

p* < 0.05, p** < 0.01, p*** < 0.001; Data Source: This Research.

In order to confirm which citation group has higher stock price mean and which citation group has lower stock price mean, Table 13 shows the multiple comparisons of ANOVA on the stock price between every two citation groups based on patent interval of six years.

In 2016, the stock price variances between B-group and A-group from Q1 to Q4, between A-group and N-group in Q4, are of significance. According to the significant mean differences, citation B-groups have higher stock price means than citation A-groups in all quarters, and citation N-group has higher stock price mean than citation A-group in Q4.

In 2017, the stock price variances between B-group and A-group in Q3 and Q4 are free of significance while the other stock price variances are of significance. According to the significant mean differences, citation N-groups have higher stock price means than citation B-groups, and citation B-groups has higher stock price means than citation A-groups.

In 2018, the stock price variance between B-group and A-group in Q3 is free of significance while the other stock price variances are of significance. According to the significant mean differences, citation N-groups have higher stock price means than citation B-groups, and citation B-groups has higher stock price means than citation A-groups.

In 2019, the stock price variances between B-group and A-group in all quarters are of significance. According to the significant mean differences, citation N-groups have higher stock price means than citation B-groups, and citation B-groups has higher stock price means than citation A-groups.

In 2020, the stock price variances between B-group and A-group in Q1 and Q4 are free of significance while the other stock price variances are of significance. According to the significant mean differences, citation N-groups have higher stock price means than citation B-groups, and citation B-groups has higher stock price means than citation A-groups.

Figure 2 shows the original stock price means without natural logarithm transformation of N-groups, B-groups and A-groups from 2016Q4 to 2020Q4. The significant stock price means show that citation N-groups have highest stock price means except in 2016Q4 while citation A-groups have the lowest stock price means in all quarters. It indicates that the A-shares with patents but without forward citations have the highest stock price means while the A-shares with patents and receiving higher forward citations have the lowest stock price means.

It is very interesting that the result come out from the aforementioned analysis is somehow against the opinion proposed by previous studies on forward citation, especially on US patent's forward citation [29,30,31]. The previous studies proposed that US companies having US patent portfolios with lots of forward citations would have better financial achievement. This research find out that China listed companies having China patent portfolios with lots of forward citations would not have better financial performance which represented by the stock price. Contrarily, they would have worse financial performance than those listed companies either with less forward citations or without any forward citations. Though the stock price might not be a perfect indicator for intensively explaining listed company's financial performance, it is appropriate to the general public for the reason of easy understanding.

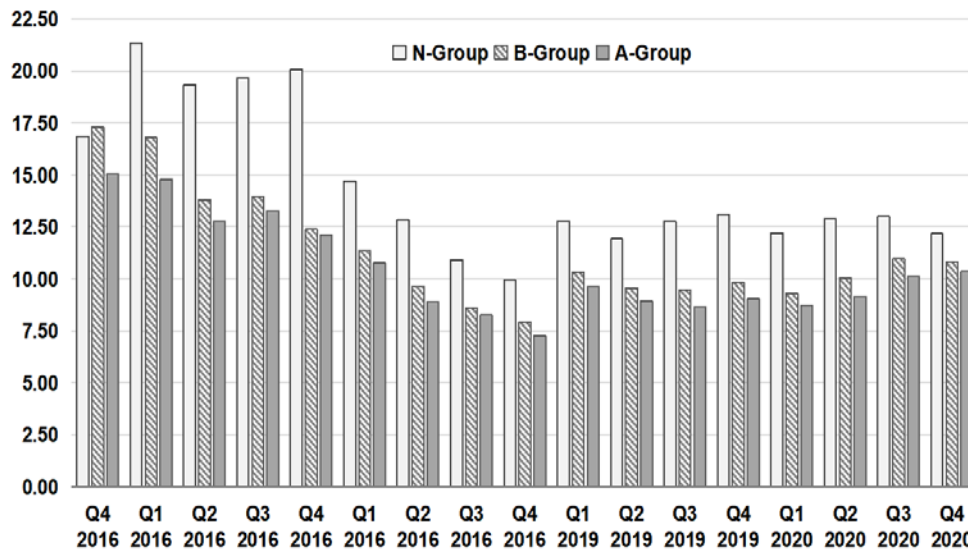


Figure 2. Comparison of Stock Price Means of Citation Groups (Data Source: Shanghai Stock Exchange and Shenzhen Stock Exchange)

Since the forward citation indicates the patent's influence on the related technology and industry, it is thought-provoking why the forward citation effect on China A-shares is so peculiar. Based on the understanding of China patent practice, it might be resulted from the following reasons.

(1) The subsidy policy previously provided by China government. For supporting mass entrepreneurship and innovation, China government had provided high preferential subsidy policy for patent application. It resulted the low cost for domestic companies to file patents in China when comparing with patent filing expense in other countries. Some administrative provinces or cities further set up the task goal of large patent amount and high patent growth rate. Companies were encouraged to file lots of patents to earn the subsidy and help the government reach the task goal simultaneously. The patent filing to some extent was not supposed to be a normal behaviour of R&D for protecting the innovation outcome. The resulting patents and their citation effect were somehow distorted.

(2) The wide gap between the innovation and efficient commercialization. Though China is the world largest patent application country, the unofficial estimation reports that the patent utilization rate in China is less than 1%. It means that there would be only ten thousand patents being utilized in real products and services among one million patents. The majority of patents are ideas on the papers rather than innovations in real products and services. In addition, even if some patents have been applied in real products or services, it is still a big fight to beat competitors for earning commercial merit. Either the patent or the high citation count is not a guarantee of customer's purchase. The patented products do not always convince clients to pay without any doubt. It is a bigger challenge for companies having high forward citation counts to make money because the way of such pioneering patents from the innovation to commercialization is much longer than that of the following-up patents. It is therefore the forward citation does not show good effect in China A-shares.

4. Conclusion and Recommendation

Based on the company integrated patent database of China A-shares and the stock price data in twenty quarters from 2016 to 2020, the impact of the patent forward citation on the stock price was thoroughly analyzed via ANOVA. Six patent intervals from one year to six years were designed for retrieving patents and calculation forward citations. The forward citation count was defined as the number of total patent forward citations which an A-share received under the specific patent interval. Thousands of A-shares in each quarter were divided into three citation groups including N-group in which the A-shares had patents but had no forward citations, B-group in which the A-shares had forward citation counts below the average, and A-group in which the A-shares had forward citation counts above the average. The following conclusions were arrived:

(1) The forward citation count variance between six patent intervals was of significance. As the length of patent interval increased, the forward citation count increased.

(2) Among six patent intervals, the patent interval of six years was preferable for calculating the forward citation count and dividing the A-shares into citation groups because the stock price variances between citation groups were all of significance in all quarters from 2016 to 2020.

(3) According to the significant mean difference, the A-shares in N-groups had the highest stock price means while the A-shares in A-groups had the lowest stock price means. The A-shares receiving more citation count did not show higher stock price mean. Contrarily, they showed lower stock price mean.

(4) The forward citation count was good for discriminating the stock price. However, this research did not agree with the previous studies. The positive effect of forward citation on the stock price did not show in China stock market. The forward citation showed negative influence on the stock price.

(5) The negative influence of the forward citation on the stock price might result from the subsidy

policy previously provided by China government and the wide gap between the innovation and efficient commercialization in China.

(6) The aforementioned conclusions had not been changed by COVID-19 though COVID-19 affected the social and economic environment to a considerable extent in 2020.

It believed that the forward citation might still have positive effect on the stock price in some specific industries in which the product's life cycle corresponds to the varying trend of the forward citation. However, it need further study based from the industrial level's perspective. The finding of this research would improve the understanding of China patents and the innovation outcome of China A-shares over the recent five years. It would also contribute the state of the art in the listed company evaluation.

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References

- [1] Liegsalz, J. and Wagner, S. "Patent Examination at the State Intellectual Property Office in China," *Research Policy*, 42(2), 552-563. 2013.
- [2] Motohashi, K. "Assessment of technological capability in science industry linkage in China by patent database," *World Patent Information*, 30(3), 225-232. 2008.
- [3] Motohashi, K. "Catching up or lagging behind? Assessment of technological capacity of China by patent database," *China Economic Journal*, 2(1), 1-24. 2009.
- [4] Hu, A.G. and Jefferson, G.H. "A great wall of patents: What is behind China's recent patent explosion?" *Journal of Development Economics*, 90, 57-68. 2009.
- [5] Lei, X.P., Zhao, Z.Y., Zhang, X., Chen, D.Z., Huang, M.H. and Zhao, Y.H. "The inventive activities and collaboration pattern of university---industry---government in China based on patent analysis," *Scientometrics*, 90(1), 231-251. 2011.
- [6] Li, X. "Behind the recent surge of Chinese patenting: an institutional view," *Research Policy*, 41(1), 236-249. 2012.
- [7] Liu, Q. and Qiu, L. D. "Intermediate input imports and innovations: Evidence from Chinese firms' patent filings," *Journal of International Economics*, 103, 166-183. 2016.
- [8] Boeing, P. and Mueller, E. "Measuring China's patent quality: Development and validation of ISR indices," *China Economic Review*, 57, 2019. 101331.
- [9] Dang, J. and Motohashi, K. "Patent statistics: A good indicator for innovation in China? Patent subsidy program impacts on patent quality," *China Economic Review*, 35(Sep), 137-155. 2015.
- [10] Chen, Z. and Zhang, J. "Types of patents and driving forces behind the patent growth in China," *Economic Modelling*, 80, 294-302. 2019.
- [11] He, Z.L., Tong, T.W., Zhang, Y. and He, W. "Constructing a Chinese patent database of listed firms in China: Descriptions, lessons, and insights," *Journal of Economics & Management Strategy*, 27(3), 579-606. 2016.
- [12] Chen, T.M., Wei, C.C. and Che, H.C. "Contribution of Patent Indicators to China Stock Performance," in *the IEEE 7th International Congress on Advanced Applied Informatics (ICAAI2018)*, 793-798, July 2018. Yonago, Japan.
- [13] Chen, T.M., Wei, C.C. and Che, H.C. "Exploring Contribution of Patents to Stock Price in China," *International Journal of Economics and Research*, 11 (i4) (ja), 01-29. 2020.
- [14] Chiu, Y.J., Chen, K.C. and Che, H.C. "Does Patent Help to Build Investment Portfolio of China A-Shares under China-US Trade Conflict?" *Mathematical Problems in Engineering*, 2020. 7317480.
- [15] Chiu, Y.J., Chen, K.C. and Che, H.C. "Patent Implemented Time Series Algorithm for Building Stock Portfolios in China A-Shares," *Asian Journal of Information and Communications*, 12(1), 156-170. 2020
- [16] Chiu, Y.J., Chen, K.C. and Che, H.C. "Patent As Predictive Indicator of Investment: An Empirical Study of China A-Shares," in *the 2020 Chinese Society for Management of Technology Conference*, 2020. Hsinchu, Taiwan.
- [17] Chiu, Y.J., Chen, K.C. and Che, H.C. "Patent Informatics in Predicting Stock Price and Increasing Investment Performance -- An Empirical Study of China Four Stock Boards," in *the 2020 International Conference on Economics, Management and Technology (IEMT2020)*, October 2020. Kaohsiung, Taiwan.
- [18] Chiu, Y.J., Chen, K.C. and Che, H.C. "Patent Informatics in Predicting Return-on-Assets (ROA) and Increasing Investment Performance in China," in *the 2020 International Conference on Business Administration - Fall Session (ICBA 2020 Fall)*, October 2020. New Taipei City, Taiwan.
- [19] Chiu, Y.J., Chen, K.C. and Che, H.C. "Using Patent to Predict Book-Value-Per-Share and Investment -- Evidence in China A-Shares," *International Journal of Innovation in Management*, 8(2), 47-64. 2020.
- [20] Chiu, Y.J., Chen, K.C. and Che, H.C. "Patent predictive price-to-book ratio (PB) on improving investment performance -- Evidence in China," *World Patent Information*, 2021. 102039.
- [21] Li, Z., Deng, G. and Che, H.C. "Patent-Based Predictive Price-to-Earnings on Increasing Investment Performance of China Stock Market," in *the 2020 International Symposium on Computational Intelligence and Design (ISCID2020)*, December 2020. Hangzhou, China.
- [22] Li, Z., Deng, G. and Che, H.C. "Patent-Based Predictive ROE on Increasing Investment Performance of China Stock Market," in *the 2020 IEEE International Conference on Computer and Communications (ICCC2020)*, December 2020. Chengdu, China.
- [23] Li, Z., Deng, G. and Che, H.C. "Patent-Based Predictive EPS on Increasing Investment Performance of China Stock Market," in *the 2021 IEEE International Conference on Power Electronics, Computer Applications (ICPECA2021)*, January 2021. Shenyang, China.
- [24] Tsai, H.W., Che, H.C. and Bai, B. "Innovation Continuity as Indicator for Observing Stock Return Rate in China Stock Market," *Advances in Management & Applied Economics*, 11(5), 25-49. 2021.
- [25] Tsai, H.W., Che, H.C. and Bai, B. "Exploring Patent Effects on Higher Stock Price and Stock Return Rate—A Study in China Stock Market," *Chinese Business Review*, 20(5), 168-180. 2021.
- [26] Tsai, H.W., Che, H.C. and Bai, B. "Exploring Technology Variety Effect on Stock Return Rate in China Stock Market," in *the 2021 7th International Conference on Industrial and Business Engineering*, September 2021. Macao, China.
- [27] Tsai, H.W., Che, H.C. and Bai, B. "How Does Patent Examination Indicate Stock Performance? An Empirical Study of China Stock Market and Patents," *Internal Journal of Economics and Research*, 12(i5), 01-29 (so). 2021.
- [28] Tsai, H.W., Che, H.C. and Bai, B. "Using Patent Backward Citation for Classifying Stock Price of China Stock Market," *Economics and Management*, XV111(2), 12-34. 2021.
- [29] Thomas, P. "A relationship between technology indicators and stock market performance," *Scientometrics*, 55(1), 319-333. 2001.
- [30] Hall, B.H., Jaffe, A. and Trajtenberg, M. "Market Value and Patent Citations," *RAND Journal of Economics*, 36(1), 16-38. 2005.
- [31] Hirshleifer, D., Hsu, P. and Li, D. "Innovative efficiency and stock returns," *Journal of Financial Economics*, 107(3), 632-654. 2013.
- [32] Lai, Y.H. and Che, H.C. "Modeling patent legal value by extension neural network," *Expert Systems with Applications*, 36 (7), 10520-10528. 2009.

- [33] Lai, Y.H. and Che, H.C. "Evaluating patents using damage awards of infringement lawsuits: A case study," *The Journal of Engineering and Technology Management*, 26, 167-180, 2009.
- [34] Lai, Y.H. and Che, H.C. "Integrated evaluator extracted from infringement lawsuits using extension neural network accommodated to patent assessment," *The International Journal of Computer Applications in Technology*, 35(2/3/4), 84-96, 2009.



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