Exploring the Relationship Between Patent Forward Citation and Stock Return Rate Using Empirical Data of China Stock Market

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Abstract

A novel indicator called price-citation was proposed. Based on the company integrated patent database of China listed companies of common stocks (A-shares) with the stock price and the stock return rate data, more than two thousand of A-shares from 2017 to 2020 were selected. The effect of the traditional patent forward citation and the price-citation for discriminating the stock return rate was thoroughly analyzed via ANOVA. The A-shares of forward citation counts above the average showed higher stock return rate means than the A-shares having patents but receiving no forward citations. The price-citation, combining both the financial and patent attributes, defined as the multiplication of the current stock price and the currently receiving forward citation count, showed its excellence in discriminating the stock return rate. The A-shares of higher price-citation showed significantly higher stock return rate means while the A-shares of lower price-citation showed significantly lowest stock return rate means. The price-citation effect had not been changed by COVID-19 though COVID-19 affected the social and economic environment to a considerable extent in 2020.

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

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 five millions of patent published and/or granted by CNIPA. 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 (Liegsalz & Wagner, 2013). Based on patent information, Motohashi (2008) examined China's development of innovation capabilities from 1985 to 2005 by using more than 679 thousands of China invention patent. Motohashi (2009) 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 (2009) 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 and Zhang et al. (2011) 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. Liu and Qiu (2016) used Chinese firm-level patent data from 1998 to 2007 which featuring a drastic input tariff cut in 2002 because of China's WTO accession. They found that input tariff cut results in less innovation undertaken by Chinese firms.

Boeing and Mueller (2019) proposed a patent quality index based on internationally comparable citation data from international search reports 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 (2015) 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 (2019) 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 et al. (2016) 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 et al. (2018, 2020) used the patent data and stock data of China listed companies of RMB 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 et al. (2020a, 2020b) 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 et al. (2020c, 2020d, 2020e, 2020f, 2021), Li et al, (2020a, 2020b, 2021) 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. The fluctuation modes of stocks are far beyond any patent indicator's varying trend. Is it possible to correlate China stock market with patent? Tsai et al, (2021a, 2021b, 2021c, 2021d, 2021e, 2021f, 2022), Chen et al. (2022) discussed the relationship between China patent indicators and China A-shares' stock performance in 2020. The A-shares with the higher innovation continuity are found to show higher stock return rate mean with regard to any China 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 with regard to any China patent species (Tsai et al., 2021b). The A-shares having patents of the higher technology variety are found to show the higher stock return rate mean (Tsai et al., 2021c). The A-shares having invention grant patents of longer examination duration are found to show higher stock return rate mean (Tsai et al., 2021d). The A-shares having patents of more backward citations are found show higher natural logarithm transformed stock price mean (Tsai et al., 2021e). The A-shares having patents of higher patent count are found to show higher stock price mean with regard to any of four China stock boards (Tsai et al., 2021f). The A-shares having invention grant patents of longer patent lives are found to show higher stock price mean with regard to any of four China stock boards (Tsai et al., 2022). The A-shares having higher total patent drawing counts of invention grants are found to show higher stock return rate mean whereas the A-shares having higher average patent drawing counts of invention grants are not (Chen et al., 2022).

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 (Thomas, 2001; Hallet al., 2005; Hirshleifer et al., 2013). Lai and Che (2009a, 2009b, 2009c) 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 (Chiu et al., 2020a~2020f, 2021; Li et al., 2020a, 2020b, 2021), however, the detailed relationship between the forward citation count and A-share's stock return rate is not yet discussed.

It is therefore the objective of this research to find out the followings:

(1) Whether China patent forward citation count significantly relates to China A-share's stock

return rate? If yes, is the significant relationship positive or negative?

(2) If no, is there any manipulation of China patent forward citation count in order to improve the significant relationship between the manipulated China patent forward citation and the stock return rate? When the significant relationship is derived, is the significant relationship positive or negative?

The managerial implication of this research therefore comprises:

(1) enriching the understanding of China patent forward citation count;

(2) extending the application of China patent forward citation count to the China stock market; and

(3) helping the investment organizations to improve their stock portfolio strategy on China A-shares by using the factor of patent forward citation count.

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. No matter what patent species is, 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 seems 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 (2001) proposed a "current impact index" which is the normalized total forward citation count calculated in the current year and the patents being cited are retrieved by the patent grant date from previous five years. Following the similar but not the same concept of Thomas (2001), the patent interval of five years for retrieving patents and calculating the forward citation count is applied in this research.

The Kolmogorov-Smirnov test is applied on the forward citation count. 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 annual stock return rate is observed and discussed. The quarter based analysis is applied on the sixteen quarters from 2017 to 2020 in this research for avoiding bias. The population comprises all China companies listed in Shanghai exchange and Shenzhen exchange, 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 return rate over previous one year in the last trading day of any quarter from 2017 to 2020; and

(2) It must have at least one new patent published or granted for calculating forward citation count during the patent interval as described in sub-section 2.2.

Table 1 shows the effective samples statistics by quarter from 2017 to 2020. Based on the world's No. 2 stock transaction volume of China, there are 3,164 active A-shares in 2017Q1 and 3,638 active A-shares in 2020Q4. The minimum sampling rate for collecting effective samples is 78.3%. The analysis in this research should be free of survivorship bias.

Table 1: Effective Samples Statistics in Every Quarter from 2017 to 2020

Year	Q1	Q2	Q3	Q4
2017	2,478	2,515	2,574	2,640
2018	2,681	2,770	2,799	2,932
2019	3,054	3,065	3,061	3,090
2020	3,140	3,173	3,263	3,262

Data Source: This Research

At the first analysis stage, the effective sample A-shares in each quarter are divided into three citation groups for testing the stock return rate variance. The definitions of three citation groups are shown below.

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

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

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

At the second analysis stage, a novel indicator called "Price-Citation" is proposed and defined as the multiplication of the current stock price and the currently receiving forward citation count. The A-shares in N-group are excluded first, then the remaining A-shares in each quarter are divided into four price-citation groups by percentile rank (PR) of price-citation count as below:

price-citation group 1: PR 0~25, the group in which the A-shares of the lowest price-citation counts;

price-citation group 2: PR 25~50;

price-citation group 3: PR 50~75;

price-citation group 4: PR 75~100, the group in which the A-shares of the highest price-citation counts.

2.4 Hypothesis Test & Analysis of Variance

Analysis of Variance (ANOVA) is applied in this research for hypothesis test to discover the followings:

(1) Whether the stock return rate means between different citation groups are significantly different or not? If yes, which citation group shows significantly higher stock return rate means and which citation group shows significantly lower stock return rate means?
(2) Whether the stock return rate means between different price-citation groups are significantly different or not? If yes, which price-citation group shows significantly higher stock return rate mean and which price-citation group shows significantly lower stock return rate mean?

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

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

This F-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 should be smaller than 0.05.

The null hypothesis in this research includes two parts:

(1) The stock return rate variance between different citation groups is provided without significance;
(2) The stock return rate variance between different price-citation groups is provided without significance.

If the p value resulted from ANOVA for aforementioned part (1) is smaller than 0.05, the null hypothesis (1) is rejected and the stock return rate variance between different citation groups is of significance. If the p value resulted from ANOVA for aforementioned part (2) is smaller than 0.05, the null hypothesis (2) is rejected and the stock return rate variance between different price-citation groups is of significance.

3. Result and Finding

3.1 Stock Return Rate in View of Forward Citation

The Kolmogorov-Smirnov test is also applied on the stock return rate. The test result shows that the original data distributions of the stock return rates in percentage are seriously skewed. Therefore, all stock return rates discussed in this research had been cox-box transformed.

In order to confirm whether the stock return rate means between citation groups are significantly different or not, Table 2 shows the results of ANOVA on the stock return rate between different citation groups. The stock return rate variances between citation groups are of significance in three quarters of 2017, three quarters of 2018, three quarters of 2019, and two quarters of 2020; whereas the stock return rate variances between citation groups are free of significance in any other quarters. In all sixteen quarters from 2017 to 2020, there are eleven quarters in which the stock return rate variances between citation groups are of significance.

Table 2: ANOVA on Stock Return Rate between Citation Groups Based on Patent Interval=5

Year	Quarter	Citation group	Stock return rate			
			Sum square	Mean square	F	p
2017	Q1	Between Groups	44.4	22.2	2.341	0.096
		Within Groups	23,455.5	9.5		
	Q2	Between Groups	88.7	44.4	5.281	0.005**
		Within Groups	21,101.0	8.4		
	Q3	Between Groups	286.4	143.2	18.454	0.001***
		Within Groups	19,951.9	7.8		
	Q4	Between Groups	348.5	174.2	25.370	0.001***
		Within Groups	18,110.0	6.9		
2018	Q1	Between Groups	213.5	106.7	22.696	0.001***
		Within Groups	12,593.3	4.7		
	Q2	Between Groups	47.6	23.8	5.541	0.004**
		Within Groups	11,898.3	4.3		
	Q3	Between Groups	25.4	12.7	5.163	0.006**
		Within Groups	6,886.1	2.5		
	Q4	Between Groups	0.9	0.5	0.289	0.749
		Within Groups	4,734.2	1.6		
2019	Q1	Between Groups	55.3	27.6	3.786	0.023*
		Within Groups	22,277.1	7.3		
	Q2	Between Groups	165.3	82.6	9.244	0.001***
		Within Groups	27,371.3	8.9		
	Q3	Between Groups	12.0	6.0	0.697	0.498
		Within Groups	26,225.5	8.6		
	Q4	Between Groups	51.6	25.8	3.838	0.022*
		Within Groups	20,761.0	6.7		
2020	Q1	Between Groups	10.1	5.0	0.613	0.542
		Within Groups	25,733.6	8.2		
	Q2	Between Groups	10.3	5.1	0.495	0.610
		Within Groups	32,983.1	10.4		
	Q3	Between Groups	152.8	76.4	8.136	0.001***
		Within Groups	30,609.8	9.4		
	Q4	Between Groups	306.4	153.2	15.329	0.001***
		Within Groups	32,574.0	10.0		

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

Table 3 shows the statistics of the stock return rate of all citation groups in the quarters of significance from 2017 to 2020. A-groups seem to have higher stock return rate means in most quarters and N-groups seem to have the lower stock return rates in all quarters.

Table 3: Stock Return Rate Statistics of Citation Groups from 2017 to 2020

Year	Quarter	Citation group	Samples	Stock return rate			
				Mean	Std. Deviation	Min.	Max.
2017	Q2	N-Group	202	-1.243	2.856	-4.434	5.239
		B-Group	1,161	-1.478	2.829	-4.473	5.646
		A-Group	1,152	-1.087	2.974	-4.479	5.454
	Q3	N-Group	235	-1.587	2.613	-4.357	5.254
		B-Group	1,205	-1.637	2.684	-4.429	5.600
		A-Group	1,134	-0.957	2.923	-4.430	5.555
	Q4	N-Group	260	-2.278	2.407	-4.339	5.013
		B-Group	1,212	-2.361	2.409	-4.501	5.797
		A-Group	1,168	-1.616	2.866	-4.445	5.670
2018	Q1	N-Group	323	-2.736	2.207	-4.517	4.746
		B-Group	1,243	-2.976	1.906	-4.478	4.491
		A-Group	1,115	-2.374	2.418	-4.466	5.282
	Q2	N-Group	404	-2.821	2.191	-4.503	4.924
		B-Group	1,256	-2.965	1.942	-4.490	4.847
		A-Group	1,110	-2.681	2.172	-4.493	4.934
	Q3	N-Group	450	-3.344	1.562	-4.505	4.600
		B-Group	1,265	-3.407	1.466	-4.488	4.856
		A-Group	1,084	-3.200	1.684	-4.476	4.303
2019	Q1	N-Group	674	-1.292	2.727	-4.455	5.012
		B-Group	1,314	-1.064	2.699	-4.414	5.647
		A-Group	1,066	-0.926	2.690	-4.533	5.848
	Q2	N-Group	737	-0.442	3.010	-4.504	5.436
		B-Group	1,268	-0.035	3.008	-4.442	5.870
		A-Group	1,060	0.172	2.953	-4.546	5.948
	Q4	N-Group	884	1.691	2.656	-4.368	6.170
		B-Group	1,204	1.962	2.541	-4.348	5.938
		A-Group	1,002	1.992	2.600	-4.382	6.189
2020	Q3	N-Group	1,049	0.668	3.108	-4.402	6.767
		B-Group	1,258	0.828	3.056	-4.300	5.677
		A-Group	956	1.207	3.027	-4.535	6.270
	Q4	N-Group	1,046	-0.056	3.176	-4.451	6.818
		B-Group	1,272	0.257	3.124	-4.328	5.865
		A-Group	944	0.727	3.195	-4.340	6.376

Data Source: This Research

In order to confirm the significantly higher and lower stock return rate means, Table 4 shows the multiple comparisons of ANOVA on the stock return rate between every two citation groups based.

Table 4: Multiple Comparisons of ANOVA on Stock Return Rate between Citation Groups

Year	Quarter	Group (X)	Group (Y)	Stock return rate		
				Mean difference (X-Y)	Std. Error	p
2017	Q2	N	B	0.235	0.221	0.288
		B	A	-0.391	0.121	0.001***
		A	N	0.156	0.221	0.479
	Q3	N	B	0.050	0.199	0.802
		B	A	-0.679	0.115	0.001***
		A	N	0.630	0.200	0.002**
	Q4	N	B	0.083	0.179	0.643
		B	A	-0.745	0.107	0.001***
		A	N	0.662	0.180	0.001***
2018	Q1	N	B	0.239	0.135	0.077
		B	A	-0.602	0.089	0.001***
		A	N	0.362	0.137	0.008**
	Q2	N	B	0.144	0.119	0.225
		B	A	-0.284	0.085	0.001***
		A	N	0.140	0.120	0.244
	Q3	N	B	0.063	0.086	0.464
		B	A	-0.207	0.065	0.001***
		A	N	0.144	0.088	0.102
2019	Q1	N	B	-0.228	0.128	0.075
		B	A	-0.138	0.111	0.215
		A	N	0.366	0.133	0.006**
	Q2	N	B	-0.407	0.138	0.003**
		B	A	-0.207	0.124	0.097
		A	N	0.614	0.143	0.001***
	Q4	N	B	-0.271	0.115	0.018*
		B	A	-0.030	0.111	0.789
		A	N	0.301	0.120	0.012*
2020	Q3	N	B	-0.160	0.128	0.211
		B	A	-0.379	0.131	0.004**
		A	N	0.539	0.137	0.001***
	Q4	N	B	-0.313	0.132	0.018*
		B	A	-0.469	0.136	0.001***
		A	N	0.783	0.142	0.001***

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

In 2017, the stock return rate variances between B-group and A-group in Q2, Q3 and Q4 are of significance; the stock return rate variances between A-group and N-group in Q3 and Q4 are of significance; while the other stock return rate variances are free of significance. According to the significant mean differences, citation A-groups have higher stock return rate means in most quarters while citation B-groups have lower stock return rate means in most quarters.

In 2018, the stock return rate variances between B-group and A-group in Q1, Q2 and Q3 are of significance; the stock return rate variance between A-group and N-group in Q1 is of significance; while the other stock return rate variances are free of significance. According to the significant mean differences, citation A-groups have higher stock return rate means in most quarters while citation B-groups have lower stock return rate means in most quarters.

In 2019, the stock return rate variances between N-group and B-group in Q2 and Q4 are of significance; the stock return rate variances between A-group and N-group in Q1, Q2 and Q4 are of significance; while the other stock return rate variances are free of significance. According to the significant mean differences, citation A-groups have higher stock return rate means in most quarters while citation N-groups have lower stock return rate means in most quarters.

In 2020, the stock return rate variance between N-group and B-group in Q4 is of significance; the stock return rate variances between B-group and A-group in Q3 and Q4 are of significance; the stock return rate variances between A-group and N-group in Q3 and Q4 are of significance. According to the significant mean differences, citation A-groups have higher stock return rate means while citation N-groups has lower stock return rate means.

Figure 1 shows the original stock return rate means of N-groups, B-groups and A-groups without cox-box transformation in the quarters of significance from 2017 to 2020. The significant stock return rate means show that citation N-groups always have lower stock return rate means while citation A-groups usually have higher stock return rate means. It indicates that the A-shares with patents and receiving higher forward citations have higher stock return rate means while the A-shares with patents but receiving no forward citations have the highest stock return rate means. However,

though the original stock return rate means of A-groups seem to be higher than B-groups, the stock return rate variances between A-group and B-group are not always of significance.

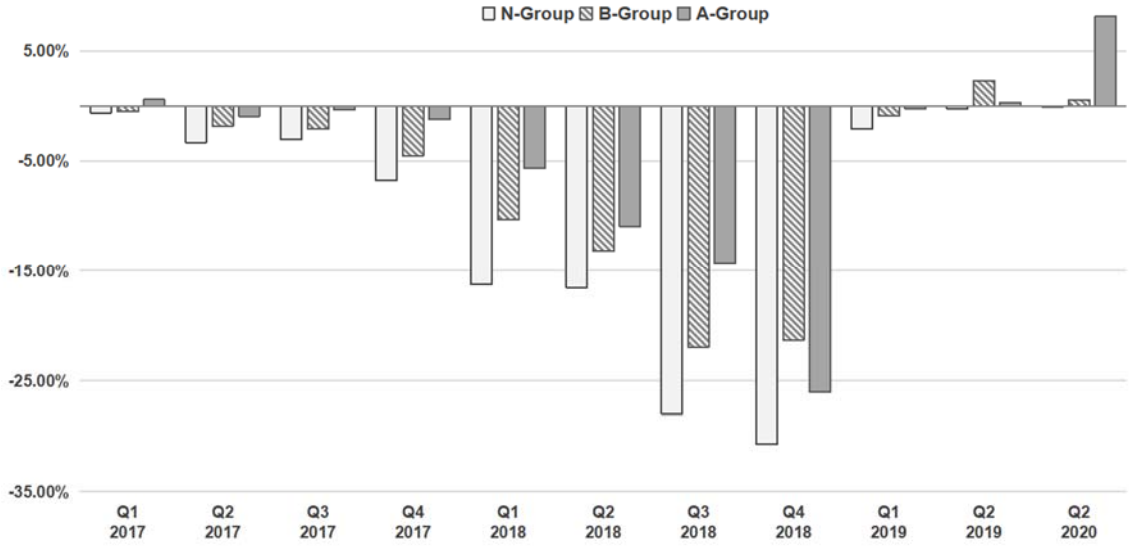

Figure 2: Comparison of Stock Return Rate Means of Citation Groups
Data Source: This Research

3.3 Stock Return Rate in View of Price-Citation

A novel indicator called "Price-Citation", which being a price-driving forward citation indicator, is further proposed in this research for classifying citation groups. The price-citation is defined as the multiplication of the current stock price and the currently receiving forward citation count, wherein, the stock price and the forward citation count are both transformed by natural logarithm. Based on the patent interval of five years, the A-shares with patents and receiving at least one forward citation are divided into four price-citation groups by percentile rank (PR) of price-citation count as below:

price-citation group 1: PR 0~25, the lowest price-citation count group;

price-citation group 2: PR 25~50;

price-citation group 3: PR 50~75;

price-citation group 4: PR 75~100, the highest price-citation count group.

Table 5 shows the result of ANOVA on stock return rate between price-citation groups. The stock return rate variances between four price-citation groups are of significance in all sixteen quarters from 2017 to 2020. Different price-citation groups have significantly different stock return rate means. In addition, the price-citation count is preferable for discriminating A-share's stock return rate when comparing with the traditional forward citation count which having eleven quarters of significance from 2017 to 2020.

Table 5: ANOVA on Stock Return Rate between Price-Citation Groups

Year	Quarter	Price-citation group	Stock return rate			
			Sum square	Mean square	F	p
2017	Q1	Between Groups	334.6	111.5	11.878	0.001***
		Within Groups	21,575.9	9.4		
	Q2	Between Groups	470.7	156.9	18.991	0.001***
		Within Groups	19,078.7	8.3		
	Q3	Between Groups	862.9	287.6	37.816	0.001***
		Within Groups	17,760.9	7.6		
	Q4	Between Groups	1,658.8	552.9	85.981	0.001***
		Within Groups	15,279.9	6.4		
2018	Q1	Between Groups	1,018.7	339.6	78.216	0.001***
		Within Groups	10,219.3	4.3		
	Q2	Between Groups	655.6	218.5	55.175	0.001***
		Within Groups	9,355.0	4.0		
	Q3	Between Groups	291.3	97.1	41.222	0.001***
		Within Groups	5,524.5	2.4		
	Q4	Between Groups	64.6	21.5	13.555	0.001***
		Within Groups	3,781.4	1.6		
2019	Q1	Between Groups	217.7	72.6	10.101	0.001***
		Within Groups	17,066.5	7.2		
	Q2	Between Groups	239.6	79.9	9.060	0.001***
		Within Groups	20,486.9	8.8		
	Q3	Between Groups	634.6	211.5	25.463	0.001***
		Within Groups	18,766.7	8.3		
	Q4	Between Groups	615.4	205.1	32.460	0.001***
		Within Groups	13,916.3	6.3		
2020	Q1	Between Groups	1,235.3	411.8	53.159	0.001***
		Within Groups	16,522.8	7.7		
	Q2	Between Groups	2,137.2	712.4	74.673	0.001***
		Within Groups	20,406.7	9.5		
	Q3	Between Groups	1,178.7	392.9	44.789	0.001***
		Within Groups	19,386.3	8.8		
	Q4	Between Groups	1,474.6	491.5	52.587	0.001***
		Within Groups	20,675.4	9.3		

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

Table 6 further shows the multiple comparisons of ANOVA on the stock return rate between every two price-citation groups. With regard to 2017, in Q1 and Q3, the stock return rate variances between price-citation groups 3 and 1, between price-citation groups 4 and 1, between price-citation groups 4 and 2, between price-citation groups 4 and 3, are of significance. In Q2, the stock return rate variances between price-citation groups 4 and 1, between price-citation groups 4 and 2, between price-citation groups 4 and 3, are of significance. In Q4, the stock return rate variances between price-citation groups 3 and 1, between price-citation groups 3 and 2, between price-citation groups 4 and 1, between price-citation groups 4 and 2, between price-citation groups 4 and 3, are of significance. According to the significantly mean differences, price-citation groups 4 have the highest stock return rate means while price-citation groups 1 have the highest stock return rate means in all quarters of 2017.

Table 6: Multiple Comparisons of ANOVA on Stock Return Rate between Price-Citation Groups

Year	Quarter	Group (X)	Group (Y)	Stock return rate		
				Mean difference (X-Y)	Std. Error	p
2017	Q1	2	1	0.285	0.180	0.115
		3	1	0.360	0.180	0.046*
		3	2	0.075	0.181	0.677
		4	1	1.040	0.181	0.001***
		4	2	0.755	0.181	0.001***
		4	3	0.680	0.181	0.001***
	Q2	2	1	0.061	0.169	0.718
		3	1	0.193	0.169	0.253
		3	2	0.132	0.169	0.435
		4	1	1.115	0.169	0.001***
		4	2	1.054	0.169	0.001***
		4	3	0.922	0.169	0.001***
	Q3	2	1	0.086	0.161	0.592
		3	1	0.352	0.161	0.029*
		3	2	0.265	0.161	0.100
		4	1	1.518	0.161	0.001***
		4	2	1.432	0.162	0.001***
		4	3	1.167	0.161	0.001***
	Q4	2	1	0.156	0.147	0.289
		3	1	0.545	0.147	0.001***
		3	2	0.389	0.147	0.008**
		4	1	2.108	0.147	0.001***
		4	2	1.952	0.147	0.001***
		4	3	1.563	0.147	0.001***
2018	Q1	2	1	0.219	0.121	0.071
		3	1	0.456	0.121	0.001***
		3	2	0.237	0.121	0.051
		4	1	1.698	0.121	0.001***
		4	2	1.479	0.122	0.001***
		4	3	1.243	0.121	0.001***
	Q2	2	1	0.101	0.116	0.384
		3	1	0.229	0.116	0.048*
		3	2	0.128	0.116	0.269
		4	1	1.312	0.116	0.001***
		4	2	1.212	0.116	0.001***
		4	3	1.084	0.116	0.001***
	Q3	2	1	0.077	0.089	0.392
		3	1	0.061	0.089	0.494
		3	2	-0.015	0.090	0.864
		4	1	0.858	0.090	0.001***
		4	2	0.781	0.090	0.001***
		4	3	0.796	0.090	0.001***
	Q4	2	1	-0.029	0.073	0.693
		3	1	0.058	0.073	0.429
		3	2	0.086	0.073	0.237
		4	1	0.383	0.073	0.001***
		4	2	0.412	0.073	0.001***
		4	3	0.326	0.073	0.001***
2019	Q1	2	1	-0.148	0.155	0.341
		3	1	0.081	0.155	0.601
		3	2	0.229	0.155	0.141
		4	1	0.651	0.155	0.001***
		4	2	0.799	0.156	0.001***
		4	3	0.570	0.156	0.001***
	Q2	2	1	0.132	0.174	0.446
		3	1	0.139	0.174	0.424
		3	2	0.006	0.174	0.970
		4	1	0.821	0.174	0.001***

Year	Quarter	Group (X)	Group (Y)	Stock return rate		
				Mean difference (X-Y)	Std. Error	p
		4	2	0.688	0.174	0.001***
		4	3	0.682	0.174	0.001***
	Q3	2	1	0.207	0.171	0.226
		3	1	0.726	0.171	0.001***
		3	2	0.519	0.171	0.002**
		4	1	1.371	0.171	0.001***
		4	2	1.164	0.171	0.001***
		4	3	0.645	0.172	0.001***
	Q4	2	1	0.235	0.151	0.121
		3	1	0.846	0.151	0.001***
		3	2	0.611	0.151	0.001***
		4	1	1.350	0.151	0.001***
		4	2	1.115	0.152	0.001***
		4	3	0.504	0.152	0.001***
2020	Q1	2	1	0.425	0.170	0.013*
		3	1	0.936	0.170	0.001***
		3	2	0.511	0.170	0.003**
		4	1	2.035	0.170	0.001***
		4	2	1.610	0.170	0.001***
		4	3	1.099	0.170	0.001***
	Q2	2	1	0.710	0.188	0.001***
		3	1	1.309	0.189	0.001***
		3	2	0.599	0.189	0.002**
		4	1	2.717	0.189	0.001***
		4	2	2.007	0.189	0.001***
		4	3	1.408	0.189	0.001***
	Q3	2	1	0.996	0.178	0.001***
		3	1	1.051	0.178	0.001***
		3	2	0.055	0.178	0.756
		4	1	2.062	0.178	0.001***
		4	2	1.066	0.178	0.001***
		4	3	1.011	0.178	0.001***
	Q4	2	1	0.653	0.184	0.001***
		3	1	1.172	0.184	0.001***
		3	2	0.519	0.184	0.005**
		4	1	2.231	0.184	0.001***
		4	2	1.577	0.184	0.001***
		4	3	1.058	0.184	0.001***

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

With regard to 2018, in Q1 and Q2, the stock return rate variances between price-citation groups 3 and 1, between price-citation groups 4 and 1, between price-citation groups 4 and 2, between price-citation groups 4 and 3, are of significance. In Q3 and Q4, the stock return rate variances between price-citation groups 4 and 1, between price-citation groups 4 and 2, between price-citation groups 4 and 3, are of significance. According to the significantly mean differences, price-citation groups 4 have the highest stock return rate means in all quarters while price-citation groups 1 have the highest stock return rate means in Q1, Q2 and Q3 of 2018.

With regard to 2019, in Q1 and Q2, the stock return rate variances between price-citation groups 4 and 1, between price-citation groups 4 and 2, between price-citation groups 4 and 3, are of significance. In Q3 and Q4, the stock return rate variances between price-citation groups 3 and 1, between price-citation groups 3 and 2, between price-citation groups 4 and 1, between price-citation groups 4 and 2, between price-citation groups 4 and 3, are of significance. According to the significantly mean differences, price-citation groups 4 have the highest stock return rate means in all quarters while price-citation groups 1 have the highest stock return rate means in Q2, Q3 and Q4 of 2019.

With regard to 2020, in Q1, Q2 and Q4, the stock return rate variances between any two price-citation groups are of significance. In Q3, the stock return rate variances between price-citation groups 2 and 1, between price-citation groups 3 and 1, between price-citation groups 4 and 1, between price-citation groups 4 and 2, between price-citation groups 4 and 3, are of significance. According to the significantly mean differences, price-citation groups 4 have the highest stock return rate means

while price-citation groups 1 have the highest stock return rate means in all quarters of 2020.

Figure 2 shows the original stock return rate means without cox-box transformation of four price-citation groups from 2017 to 2020. The significant stock return rate means show that price-citation groups 4 always have higher stock return rate means while price-citation groups 1 usually have the lowest stock return rate means. It indicates that the A-shares with higher price-driving forward citations show higher stock return rate means while the A-shares with lower price-driving forward citations show lower stock return rate means.

If taking the annual stock return rate as one of indicators of company's financial performance, the result come out from the aforementioned analysis, based on China stock market and China patents, does not fully agrees with previous studies on forward citation, especially on US patent's forward citation (Thomas, 2001; Hall et al., 2005; Hirshleifer et al., 2013). 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 the forward citation count could only be applied for discriminating the stock return rate means between the A-shares receiving no forward citations and the A-shares receiving lots of forward citations. In addition, the stock return rate variance between the A-shares receiving higher forward citation counts and the A-shares receiving lower forward citation counts is seldom of significance. However, a price-driving forward citation called price-citation is first proposed in this research. It proved that the price-citation is more preferable than the traditional forward citation for discriminating the A-share's stock return rate. The A-shares with higher price-citation counts show higher stock return rate means while the A-shares with lower price-citation counts show lower stock return rate means.

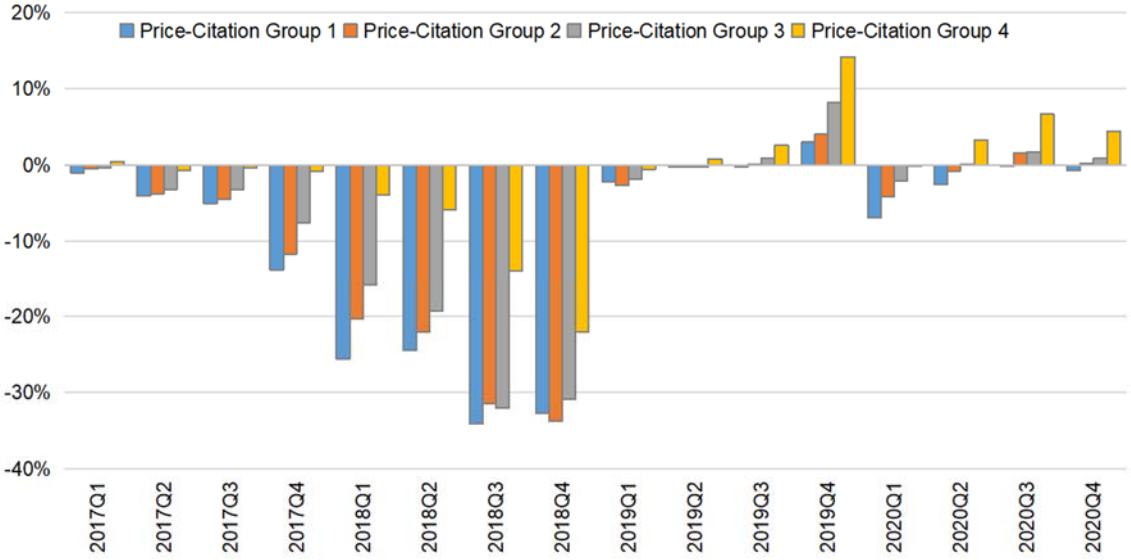

Figure 2: Comparison of Stock Return Rate Means of Price-Citation Groups
Data Source: This Research

4. Conclusion and Recommendation

A novel indicator called price-citation was proposed in this research. Based on the company integrated patent database of China A-shares with the stock price and the stock return rate data, the effect of the forward citation and the price-citation for discriminating the stock return rate was thoroughly analyzed via ANOVA. The forward citation count was defined as the number of total patent forward citations which an A-share received under the patent interval of five years. The price-citation is defined as the multiplication of the current stock price and the currently receiving forward citation count. More than two thousands of China A-shares in sixteen quarters from 2017 to 2020 were analyzed. The following conclusions were arrived:

According to the significant mean difference, the A-shares receiving the forward citation count above the average showed higher stock return rate means while the A-shares having patents but receiving no forward citation count showed the lowest stock return rate means.

For the A-shares which receiving at least one forward citation, the price-citation was shown to be preferable than the traditional forward citation for discriminating the stock return rate. The A-shares of higher price-citation showed significantly higher stock return rate means while the A-shares of lower price-citation showed significantly lowest stock return rate means. The price-citation effect had not been changed by COVID-19 though COVID-19 affected the social and economic environment to a considerable extent in 2020.

The stock return rate, being simple but clear, was an important indicator for observing the listed company's performance. The indicator of price-citation combining both the financial and patent attributes showed its excellence in discriminating the stock return rate. The finding of this research would improve the understanding of China patents and the innovation outcome of China A-shares over the recent years. It would also contribute the state of the art in the listed company evaluation.

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