Patent Effects on Higher Stock Price - An Insight into China Stock Market and Four Stock Boards

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Abstract

Based on the patent and stock price data of whole listed companies (A-shares) in China stock market, the patent effects of four patent species including the invention publication, the invention grant, the utility model grant, and the design grant, on the stock price were analyzed via ANOVA. It was proved that the A-shares having new patents of any patent species shown the higher stock price mean than those A-shares having no new patents in the whole stock market. Four stock boards including SH main board, SZ main board, GE board and SME board followed the similar conclusion to the whole stock market though some variance existing there between. With regard to the A-shares of new patents, the A-shares having new design grants were found to show the highest stock price mean while the A-shares having new utility model grants shown the lowest stock price mean. The design grant, beyond the expectation, showed outstanding patent effects on the higher stock price. The finding would improve the state of the art in the patent valuation and the listed company evaluation.

Keywords: Patent species, stock price, ANOVA, China A-share

1. Introduction

The stock market provides a trading platform where shares of publicly-held companies are sold and bought. The stock exchanges are an invaluable source of capital for businesses. The behavior of a country's stock markets can serve as a reliable indicator of national economic performance. The Investments in the financial markets drive the economic trade, growth and prosperity. Increasingly more people are looking to invest in companies with growth potential. In addition, stock exchanges with high market values can attract foreign companies. Businesses can issue share to the public, raising vast amounts of cash that doesn't come along with a repayment burden. When businesses have access to such capital, they can expand their operations and create more job opportunities. From a national perspective, this will lower unemployment levels, and enable a government to earn move revenue from business taxes.

In addition to the financial aspect, the innovation is an essential driver to the economic progress that benefits businesses and the economy as a whole. Most economists agree that technological innovation is a key driver of economic growth and the stock market usually reflects the economic conditions of an economy.

Via the positive innovation policy of government, China has been the largest patent application country in the world for years. China patent database is also the world's largest patent database. Meanwhile, China is now the world No.2 economy and having a stock market with the world No.2 transaction volume. The patents of listed companies and the patent effects on the financial performance of listed companies in China stock market become the benchmark to those tens of thousands of unlisted companies.

2. Literature Review

Hu and Jefferson (2009) used a firm-level data set that spans the population of China's large and medium-size industrial enterprises, explored the factors that account for China's rising patent activity. They found the growth of foreign direct investment in China, the amendments to the patent law emerge are significant sources of China's patent boom.

Li (2012) found that China's patent subsidy programs induced an increase in patent propensity. The patent grant ratio increased after the implementation of subsidy programs.

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. He et al. (2016) found it is difficult in integrating Chinese patent data with company data. They constructed a China patent database of all China listed companies and their subsidiaries from 1990 to 2010. Chen, Wei and Che (2018) focused China listed companies of RMB common stocks (A-shares) in Shanghai stock exchange from 2011 to 2017 to study the patent indicators' leading effect on the stock price.

Chiu, Chen and Che (2020[a, b, c]) focused on the whole China A-shares without distinguishing the stock boards from 2016Q4 to 2018Q3. They

studied the patent indicators' leading effect and proposed the patent prediction equations on 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 China A-shares are listed on four stock boards including Shanghai main board (SH main board), Shenzhen main board (SZ main board), Growing-Enterprises board (GE board) and Small-and-Medium Enterprises board (SME board). Chiu, Chen and Che (2020[d, e], 2021), Li, Deng and Che (2020[a, b], 2021) further studied each stock board's patent leading effect, 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 the performance surpassing the market trend.

Chiu et al. (2020[a, b, c, d, e], 2021) and Li, et al. (2020[a, b], 2021) applied hundreds of valid patent indicators and complicated algorithm. However, the fundamental patent effects on the stock price and the derivative return rate have not not been thoroughly studied. It is the objective of this research to solve.

3. Methodology

3.1 Patent Species and Patent Collection Interval

There are four patent species of published patents in China including the invention publication, the utility model grant, the design grant, and the invention grant. The invention grant which being the only species overcoming both the preliminary examination and the substantial examination is usually regarded as the most valuable. The other three patent species need to overcome the preliminary examination only, wherein, the design grant is always regarded as valueless. With regard to the invention grant, the utility model grant and the design grant, the annual fee must be paid to the government regularly to maintain its validity. With regard to the invention publication, if it failed the substantial examination or failed to request the substantial examination within the legal time, it is determined to be invalid. The valid patents are therefore regarded as more important than the invalid patents. In this research, the valid China patents of four patent species are discussed.

3.2 Population and Sample

The population comprises China A-shares listed in Shanghai stock exchange and Shenzhen stock exchange. For those A-shares whose subsidiaries' revenue merged with the parent company in the annual report, the patents of such parent company are merged with those of the subsidiaries for calculation.

By the end of 2020, there are more than 4,000 A-shares in China stock market. An effective sample must be listed in 2019 and 2020 so as to have a definite stock closing price and a definite annual stock return rate in the last trading day of any quarter of 2020. Table 1 shows the statistics of A-shares in four quarters of 2020, wherein, the whole stock market consists of SH main board, SZ main board, GE board and SME board. The number of effective samples in each quarter of 2020 is 3,569, the number of whole effective samples is 14,276.

Table 1: A-share Statistics in 2020

Stock Board	Number of Effective Samples				
	2020Q1	2020Q2	2020Q3	2020Q4	Total
Whole Stock Market	3,569	3,569	3,569	3,569	14,276
SH Main Board	1,447	1,447	1,447	1,447	5,788
SZ Main Board	457	457	457	457	1,828
GE Board	743	743	743	743	2,972
SME board	922	922	922	922	3,688

In order to verify the patent effect, five patent intervals are set for collecting valid patents, which are one year, two years, three years, four years and five years. Table 2 shows the statistics of A-share effective samples having and having no with regard to each patent interval, wherein, "(n)" means having no patents in the specified patent interval, and "(y)" means having at least one new patent in the specified patent interval. With regard to four patent species, the A-shares having invention publications are in the majority, while the A-shares having design grants are in the minority. For the patent interval of one year with regard to the whole stock market, the A-shares having invention publications play 73.6% of all A-shares; the A-shares having design grants are only 33.0% of all A-shares.

Table 2: A-share Statistics With/Without Patents in Patent Intervals

Patent Species	Stock Board		Number of A-shares in Patent Interval				
			1 year	2 years	3 years	4 years	5 years
Invention Publications	Whole Stock Market	(n)	3,826	2,787	2,454	2,235	2,053
		(y)	10,450	11,489	11,822	12,041	12,223
	SH Main Board	(n)	1,841	1,454	1,331	1,213	1,119
		(y)	3,947	4,334	4,477	4,575	4,669

Patent Species	Stock Board		Number of A-shares in Patent Interval				
			1 year	2 years	3 years	4 years	5 years
	SZ Main Board	(n)	712	562	520	476	434
		(y)	1,116	1,266	1,308	1,352	1,394
	GE Board	(n)	511	275	191	163	146
		(y)	2,461	2,697	2,781	2,809	2,826
	SME board	(n)	762	496	432	383	354
		(y)	2,926	3,192	3,256	3,305	3,334
Utility Model Grants	Whole Stock Market	(n)	4,250	3,472	3,073	2,785	2,497
		(y)	10,026	10,804	11,203	11,491	11,779
	SH Main Board	(n)	1,963	1,686	1,518	1,388	1,239
		(y)	3,825	4,102	4,270	4,400	4,549
	SZ Main Board	(n)	718	623	578	517	457
		(y)	1,110	1,205	1,250	1,311	1,371
	GE Board	(n)	720	527	447	410	367
		(y)	2,252	2,445	2,525	2,562	2,605
	SME board	(n)	849	636	530	470	434
		(y)	2,839	3,052	3,158	3,218	3,254
Design Grants	Whole Stock Market	(n)	9,440	8,376	7,724	7,274	6,827
		(y)	4,836	5,900	6,552	7,002	7,449
	SH Main Board	(n)	3,957	3,582	3,348	3,180	3,000
		(y)	1,831	2,206	2,440	2,608	2,788
	SZ Main Board	(n)	1,332	1,198	1,110	1,033	943
		(y)	496	630	728	795	885
	GE Board	(n)	1,874	1,640	1,485	1,398	1,314
		(y)	1,098	1,332	1,485	1,574	1,658
	SME board	(n)	2,777	1,956	1,789	1,663	1,570
		(y)	1,411	1,732	1,899	2,052	2,118
Invention Grants	Whole Stock Market	(n)	5,940	4,244	3,516	3,105	2,728
		(y)	8,336	10,032	10,760	11,171	11,548
	SH Main Board	(n)	2,734	2,135	1,835	1,643	1,483
		(y)	3,054	3,653	3,953	4,145	4,305
	SZ Main Board	(n)	934	762	698	646	562
		(y)	894	1,066	1,130	1,182	1,266
	GE Board	(n)	943	494	345	281	232
		(y)	2,029	2,478	2,627	2,691	2,740
	SME board	(n)	1,329	853	638	535	451
		(y)	2,359	2,835	3,050	3,153	3,237

3.3 Analysis of Variance

Analysis of Variance (ANOVA) is applied for discovering whether the patent effects the stock price and the stock price return rate or not. ANOVA is a statistical approach used to compare variances across the means of different data groups. The outcome of ANOVA is the "F-statistic".

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

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

4. Result and Discussion

Table 3 shows the stock price means of A-shares with and without patents with regard to each patent species, each patent interval and each stock board. For most patent species except the utility model grant, it seems that the A-shares with patents have higher stock price means than those A-shares without patents. The inference is then tested via ANOVA.

Table 3: Stock Price Means With/Without Patents

Patent Species	Stock Board		Stock Price Mean (RMB) in Patent Interval				
			1 year	2 years	3 years	4 years	5 years
Invention Publications	Whole Stock Market	(n)	12.04	11.53	11.45	11.46	11.67
		(y)	17.67	17.28	17.14	17.03	16.91
	SH Main Board	(n)	11.97	11.44	11.43	11.44	11.86
		(y)	18.40	18.00	17.79	17.65	17.43
	SZ Main Board	(n)	7.43	7.03	7.05	6.83	6.66
		(y)	13.53	12.98	12.78	12.67	12.55

Patent Species	Stock Board		Stock Price Mean (RMB) in Patent Interval				
			1 year	2 years	3 years	4 years	5 years
	GE Board	(n)	14.37	14.05	13.51	13.88	14.26
		(y)	22.19	21.78	21.70	21.62	21.58
	SME board	(n)	11.26	11.16	11.63	11.65	11.38
		(y)	14.47	14.22	14.10	14.06	14.06
Utility Model Grants	Whole Stock Market	(n)	15.10	15.10	15.47	15.55	15.46
		(y)	16.61	16.50	16.35	16.31	16.31
	SH Main Board	(n)	14.43	14.21	14.46	14.72	15.10
		(y)	17.34	17.23	17.02	16.87	16.69
	SZ Main Board	(n)	10.14	10.28	10.45	8.78	6.96
		(y)	11.80	11.60	11.48	12.09	12.55
	GE Board	(n)	25.22	26.45	27.79	28.98	30.41
		(y)	20.69	20.78	20.73	20.64	20.57
	SME board	(n)	12.27	12.79	13.44	13.76	12.81
		(y)	14.27	14.02	13.87	13.81	13.94
Design Grants	Whole Stock Market	(n)	14.27	14.25	14.42	14.38	14.46
		(y)	19.85	18.87	18.22	18.02	17.72
	SH Main Board	(n)	13.59	13.40	13.43	13.27	13.43
		(y)	22.32	21.14	20.36	20.11	19.49
	SZ Main Board	(n)	8.39	7.65	7.69	7.56	7.28
		(y)	18.56	17.80	16.38	15.81	15.27
	GE Board	(n)	21.89	22.79	23.57	23.93	24.25
		(y)	21.61	20.56	20.00	19.88	19.84
	SME board	(n)	12.62	12.68	12.77	12.69	12.53
		(y)	15.73	15.08	14.78	14.73	14.76
Invention Grants	Whole Stock Market	(n)	13.16	12.84	12.70	12.20	12.14
		(y)	18.30	17.57	17.29	17.26	17.11
	SH Main Board	(n)	13.55	13.25	13.33	12.51	12.52
		(y)	18.86	18.16	17.76	17.87	17.67
	SZ Main Board	(n)	7.89	7.87	7.58	7.74	7.76
		(y)	14.56	13.49	13.36	13.02	12.66
	GE Board	(n)	19.32	20.12	21.08	21.51	21.95
		(y)	22.93	22.12	21.88	21.82	21.78
	SME board	(n)	11.69	12.03	11.99	11.76	11.27
		(y)	15.00	14.34	14.19	14.16	14.16

Table 4 shows the result of ANOVA on the stock price between two groups (n) and (y), i.e., A-shares having no invention publications and A-shares having invention publications. With regard to the whole stock market, SH main board and SZ main board, the stock price variances between the A-shares having invention publications and the A-shares having no invention publications reach p***≤0.001 significance for all patent intervals from one year to five years. The A-shares with new invention publications have significantly higher stock price means than those without new invention publications for the whole stock market, SH main board and SZ main board as shown in Table 3.

With regard to GE boards, the stock price variances between the A-shares having invention publications and the A-shares having no invention publications are not of significance for any of five patent intervals. Though the stock price means of the A-shares with new invention publications and the A-shares look like different for GE board as shown in Table 3, the differences are not of significance for any of five patent intervals.

With regard to SME board, the stock price variances between the A-shares having invention publications and the A-shares having no invention publications are of significance, wherein, the variances reach p***≤0.001 significance for patent intervals of one year and two years, the variances reach p**≤0.01 significance for patent intervals of three years and five years, and the variance reaches p* <0.5 significance for patent interval of four years. The A-shares with new invention publications have significantly higher stock price means than those without new invention publications for SME board as shown in Table 3.

Table 4: ANOVA on Stock Price between Invention Publication Groups

Stock Board	Patent Interval	Groups (n) & (y)	Stock Price			
			Sum Square	Mean Square	F	p
Whole Stock Market	1	Between Groups	88,920.9	88,920.9	64.631	0.001***
		Within Groups	19,638,552.7	1,375.8		
		All	19,727,473.6			
	2	Between Groups	74,347.5	74,347.5	53.998	0.001***

Stock Board	Patent Interval	Groups (n) & (y)	Stock Price			
			Sum Square	Mean Square	F	p
		Within Groups	19,653,126.1	1,376.8		
		All	19,727,473.6			
	3	Between Groups	65,838.3	65,838.3	47.797	0.001***
		Within Groups	19,661,635.3	1,377.4		
		All	19,727,473.6			
	4	Between Groups	58,539.5	58,539.5	42.483	0.001***
		Within Groups	19,668,934.0	1,378.0		
		All	19,727,473.6			
	5	Between Groups	48,321.8	48,321.8	35.050	0.001***
		Within Groups	19,679,151.8	1,378.7		
		All	19,727,473.6			
SH Main Board	1	Between Groups	51,869.8	51,869.8	21.744	0.001***
		Within Groups	13,802,346.8	2,385.5		
		All	13,854,216.6			
	2	Between Groups	46,928.4	46,928.4	19.666	0.001***
		Within Groups	13,807,288.2	2,386.3		
		All	13,854,216.6			
	3	Between Groups	41,000.5	41,000.5	17.174	0.001***
		Within Groups	13,813,216.0	2,387.4		
		All	13,854,216.6			
	4	Between Groups	37,002.3	37,002.3	15.495	0.001***
		Within Groups	13,817,214.2	2,388.0		
		All	13,854,216.6			
	5	Between Groups	27,938.9	27,938.9	11.692	0.001***
		Within Groups	13,826,277.7	2,389.6		
		All	13,854,216.6			
SZ Main Board	1	Between Groups	16,192.4	16,192.4	21.570	0.001***
		Within Groups	1,370,777.4	750.7		
		All	1,386,969.8			
	2	Between Groups	13,784.9	13,784.9	18.331	0.001***
		Within Groups	1,373,184.9	752.0		
		All	1,386,969.8			
	3	Between Groups	12,242.2	12,242.2	16.261	0.001***
		Within Groups	1,374,727.6	752.9		
		All	1,386,969.8			
	4	Between Groups	12,001.0	12,001.0	15.938	0.001***
		Within Groups	1,374,968.8	753.0		
		All	1,386,969.8			
	5	Between Groups	11,485.4	11,485.4	15.247	0.001***
		Within Groups	1,375,484.5	753.3		
		All	1,386,969.8			
GE Board	1	Between Groups	2,297.8	2,297.8	2.221	0.136
		Within Groups	3,072,186.3	1,034.4		
		All	3,074,484.1			
	2	Between Groups	1.6	1.6	0.002	0.969
		Within Groups	3,074,482.5	1,035.2		
		All	3,074,484.1			
	3	Between Groups	359.5	359.5	0.347	0.556
		Within Groups	3,074,124.6	1,035.1		
		All	3,074,484.1			
	4	Between Groups	1,434.2	1,434.2	1.386	0.239
		Within Groups	3,073,049.9	1,034.7		
		All	3,074,484.1			
	5	Between Groups	2,458.2	2,458.2	2.377	0.123
		Within Groups	3,072,025.9	1,034.4		
		All	3,074,484.1			
SME Board	1	Between Groups	6,230.7	6,230.7	18.448	0.001***
		Within Groups	1,244,927.4	337.7		
		All	1,251,158.2			
	2	Between Groups	4,014.9	4,014.9	11.866	0.001***
		Within Groups	1,247,143.3	338.3		
		All	1,251,158.2			
	3	Between Groups	2,329.9	2,329.9	6.877	0.009**
		Within Groups	1,248,828.3	338.8		
		All	1,251,158.2			

Stock Board	Patent Interval	Groups (n) & (y)	Stock Price			
			Sum Square	Mean Square	F	p
	4	Between Groups	1,992.9	1,992.9	5.881	0.015*
		Within Groups	1,249,165.3	338.9		
		All	1,251,158.2			
	5	Between Groups	2,298.5	2,298.5	6.784	0.009**
		Within Groups	1,248,859.7	338.8		
		All	1,251,158.2			

p*<0.05, p**≤0.01, p***≤0.001

With regard to the effect of utility model grants, Table 5 shows the result of ANOVA on the stock price between two groups (n) and (y), i.e., A-shares having no utility model grants and A-shares having utility model grants. With regard to the whole stock market and SME board, the stock price variances between the A-shares having utility model grants and the A-shares having no utility model grants reach p*<0.05 significance only for patent interval of one year. Based on patent interval of one year, the A-shares with new utility model grants have significantly higher stock price means than those without new utility model grants for the whole stock market and SME board as shown in Table 3.

With regard to SH main board, the stock price variances between the A-shares having utility model grants and the A-shares having no utility model grants reach p*<0.05 significance for patent intervals of one year and two years. Based on these two patent intervals, the A-shares with new utility model grants have significantly higher stock price means than those without new utility model grants for SH main board as shown in Table 3.

With regard to SZ main board, the stock price variances between the A-shares having utility model grants and the A-shares having no utility model grants are of significance for patent intervals of four year and five years. Based on these two patent intervals, the A-shares with new utility model grants have significantly higher stock price means than those without new utility model grants for SZ main board as shown in Table 3.

With regard to GE board, the stock price variances between the A-shares having utility model grants and the A-shares having no utility model grants reach p***≤0.001 significance for all patent intervals from one year to five years. The A-shares with new utility model grants have significantly higher stock price means than those without new utility model grants for GE board as shown in Table 3.

Table 5: ANOVA on Stock Price between Utility Model Grant Groups

Stock Board	Patent Interval	Groups (n) & (y)	Stock Price			
			Sum Square	Mean Square	F	p
Whole Stock Market	1	Between Groups	6,749.8	6,749.8	4.886	0.027*
		Within Groups	19,720,723.8	1,381.6		
		All	19,727,473.6			
	2	Between Groups	5,130.9	5,130.9	3.713	0.054
		Within Groups	19,722,342.7	1,381.7		
		All	19,727,473.6			
	3	Between Groups	1,858.8	1,858.8	1.345	0.246
		Within Groups	19,725,614.8	1,381.9		
		All	19,727,473.6			
	4	Between Groups	1,273.3	1,273.3	0.921	0.337
		Within Groups	19,726,200.3	1,382.0		
		All	19,727,473.6			
	5	Between Groups	1,479.9	1,479.9	1.071	0.301
		Within Groups	19,725,993.7	1,382.0		
		All	19,727,473.6			
SH Main Board	1	Between Groups	10,926.8	10,926.8	4.567	0.033*
		Within Groups	13,843,289.8	2,392.5		
		All	13,854,216.6			
	2	Between Groups	10,917.4	10,917.4	4.563	0.033*
		Within Groups	13,843,299.2	2,392.6		
		All	13,854,216.6			
	3	Between Groups	7,337.5	7,337.5	3.066	0.080
		Within Groups	13,846,879.1	2,393.2		
		All	13,854,216.6			
	4	Between Groups	4,868.4	4,868.4	2.034	0.154
		Within Groups	13,849,348.1	2,393.6		
		All	13,854,216.6			
	5	Between Groups	2,485.4	2,485.4	1.038	0.308
		Within Groups	13,851,731.2	2,394.0		

Stock Board	Patent Interval	Groups (n) & (y)	Stock Price			
			Sum Square	Mean Square	F	p
		All	13,854,216.6			
SZ Main Board	1	Between Groups	1,206.5	1,206.5	1.590	0.208
		Within Groups	1,385,763.4	758.9		
		All	1,386,969.8			
	2	Between Groups	719.1	719.1	0.947	0.331
		Within Groups	1,386,250.7	759.2		
		All	1,386,969.8			
	3	Between Groups	416.6	416.6	0.549	0.459
		Within Groups	1,386,553.3	759.3		
		All	1,386,969.8			
	4	Between Groups	4,059.7	4,059.7	5.360	0.021*
		Within Groups	1,382,910.2	757.3		
		All	1,386,969.8			
	5	Between Groups	10,694.3	10,694.3	14.189	0.001***
		Within Groups	1,376,275.5	753.7		
		All	1,386,969.8			
GE Board	1	Between Groups	11,180.9	11,180.9	10.840	0.001***
		Within Groups	3,063,303.2	1,031.4		
		All	3,074,484.1			
	2	Between Groups	13,921.7	13,921.7	13.510	0.001***
		Within Groups	3,060,562.4	1,030.5		
		All	3,074,484.1			
	3	Between Groups	18,972.5	18,972.5	18.442	0.001***
		Within Groups	3,055,511.6	1,028.8		
		All	3,074,484.1			
	4	Between Groups	24,615.8	24,615.8	23.971	0.001***
		Within Groups	3,049,868.3	1,026.9		
		All	3,074,484.1			
	5	Between Groups	31,123.5	31,123.5	30.373	0.001***
		Within Groups	3,043,360.6	1,024.7		
		All	3,074,484.1			
SME Board	1	Between Groups	2,592.7	2,592.7	7.654	0.006**
		Within Groups	1,248,565.5	338.7		
		All	1,251,158.2			
	2	Between Groups	789.8	789.8	2.328	0.127
		Within Groups	1,250,368.3	339.2		
		All	1,251,158.2			
	3	Between Groups	82.1	82.1	0.242	0.623
		Within Groups	1,251,076.1	339.4		
		All	1,251,158.2			
	4	Between Groups	1.3	1.3	0.004	0.951
		Within Groups	1,251,156.9	339.4		
		All	1,251,158.2			
	5	Between Groups	487.9	487.9	1.438	0.231
		Within Groups	1,250,670.3	339.3		
		All	1,251,158.2			

p*<0.05, p**≤0.01, p***≤0.001

With regard to the patent effect of design grants, Table 6 shows the result of ANOVA on the stock price between two groups (n) and (y), i.e., A-shares having no design grants and A-shares having design grants. With regard to the whole stock market, SH main board, SZ main board ans SME board, the stock price variances between the A-shares having design grants and the A-shares having no design grants reach p***≤0.001 significance for all patent intervals from one year to five years. The A-shares with new design grants have significantly higher stock price means than those without new design grants for the whole stock market, SH main board, SZ main board and SME board as shown in Table 3.

With regard to GE boards, the stock price variances between the A-shares having design grants and the A-shares having no design grants are of significance for patent intervals of three years, four years and five years. Though the stock price means of the A-shares with new design grants and the A-shares look like different for GE board as shown in Table 3, the differences are not of significance for any of five patent intervals.

Table 6: ANOVA on Stock Price between Design Grant Groups

Stock Board	Patent Interval	Groups (n) & (y)	Stock Price			
			Sum Square	Mean Square	F	p
Whole Stock Market	1	Between Groups	99,581.8	99,581.8	72.419	0.001***
		Within Groups	19,627,891.8	1,375.1		
		All	19,727,473.6			
	2	Between Groups	74,070.0	74,070.0	53.796	0.001***
		Within Groups	19,653,403.5	1,376.9		
		All	19,727,473.6			
	3	Between Groups	51,261.1	51,261.1	37.187	0.001***
		Within Groups	19,676,212.5	1,378.5		
		All	19,727,473.6			
	4	Between Groups	47,278.7	47,278.7	34.291	0.001***
		Within Groups	19,680,194.9	1,378.7		
		All	19,727,473.6			
	5	Between Groups	37,954.0	37,954.0	27.515	0.001***
		Within Groups	19,689,519.6	1,379.4		
		All	19,727,473.6			
SH Main Board	1	Between Groups	95,334.9	95,334.9	40.091	0.001***
		Within Groups	13,758,881.7	2,378.0		
		All	13,854,216.6			
	2	Between Groups	81,746.5	81,746.5	34.343	0.001***
		Within Groups	13,772,470.1	2,380.3		
		All	13,854,216.6			
	3	Between Groups	67,600.6	67,600.6	28.371	0.001***
		Within Groups	13,786,616.0	2,382.8		
		All	13,854,216.6			
	4	Between Groups	67,151.1	67,151.1	28.181	0.001***
		Within Groups	13,787,065.4	2,382.8		
		All	13,854,216.6			
	5	Between Groups	53,000.3	53,000.3	22.220	0.001***
		Within Groups	13,801,216.3	2,385.3		
		All	13,854,216.6			
SZ Main Board	1	Between Groups	37,408.1	37,408.1	50.614	0.001***
		Within Groups	1,349,561.7	739.1		
		All	1,386,969.8			
	2	Between Groups	42,523.8	42,523.8	57.755	0.001***
		Within Groups	1,344,446.1	736.3		
		All	1,386,969.8			
	3	Between Groups	33,058.8	33,058.8	44.586	0.001***
		Within Groups	1,353,911.0	741.5		
		All	1,386,969.8			
	4	Between Groups	30,572.8	30,572.8	41.157	0.001***
		Within Groups	1,356,397.1	742.8		
		All	1,386,969.8			
	5	Between Groups	29,133.1	29,133.1	39.178	0.001***
		Within Groups	1,357,836.7	743.6		
		All	1,386,969.8			
GE Board	1	Between Groups	55.1	55.1	0.053	0.818
		Within Groups	3,074,429.0	1,035.2		
		All	3,074,484.1			
	2	Between Groups	3,656.9	3,656.9	3.537	0.060
		Within Groups	3,070,827.2	1,033.9		
		All	3,074,484.1			
	3	Between Groups	9,453.8	9,453.8	9.161	0.002**
		Within Groups	3,065,030.3	1,032.0		
		All	3,074,484.1			
	4	Between Groups	12,149.8	12,149.8	11.783	0.001***
		Within Groups	3,062,334.3	1,031.1		
		All	3,074,484.1			
	5	Between Groups	14,232.2	14,232.2	13.813	0.001***
		Within Groups	3,060,251.8	1,030.4		
		All	3,074,484.1			
SME Board	1	Between Groups	8,452.5	8,452.5	25.071	0.001***
		Within Groups	1,242,705.7	337.1		
		All	1,251,158.2			

Stock Board	Patent Interval	Groups (n) & (y)	Stock Price			
			Sum Square	Mean Square	F	p
	2	Between Groups	5,316.9	5,316.9	15.731	0.001***
		Within Groups	1,245,841.2	338.0		
		All	1,251,158.2			
	3	Between Groups	3,704.8	3,704.8	10.947	0.001***
		Within Groups	1,247,453.4	338.4		
		All	1,251,158.2			
	4	Between Groups	3,792.2	3,792.2	11.206	0.001***
		Within Groups	1,247,366.0	338.4		
		All	1,251,158.2			
	5	Between Groups	4,484.2	4,484.2	13.258	0.001***
		Within Groups	1,246,674.0	338.2		
		All	1,251,158.2			

p*<0.05, p**≤0.01, p***≤0.001

With regard to the patent effect of invention grants, Table 7 shows the result of ANOVA on the stock price between two groups (n) and (y), i.e., A-shares having no invention grants and A-shares having invention grants. With regard to the whole stock market, SH main board, SZ main board ans SME board, the stock price variances between the A-shares having invention grants and the A-shares having no invention grants are of significance for all patent intervals from one year to five years. The A-shares with new invention grants have significantly higher stock price means than those without new invention grants for the whole stock market, SH main board, SZ main board and SME board as shown in Table 3.

With regard to GE boards, the stock price variance between the A-shares having invention grants and the A-shares having no invention grants is of significance only for patent intervals of one year. Based on patent interval of one year, the A-shares with new invention grants have significantly higher stock price mean than those without new invention grants for GE board as shown in Table 3.

Table 7: ANOVA on Stock Price between Invention Grant Groups

Stock Board	Patent Interval	Groups (n) & (y)	Stock Price			
			Sum Square	Mean Square	F	p
Whole Stock Market	1	Between Groups	91,619.2	91,619.2	66.601	0.001***
		Within Groups	19,635,854.4	1,375.6		
		All	19,727,473.6			
	2	Between Groups	66,637.7	66,637.7	48.380	0.001***
		Within Groups	19,660,835.8	1,377.4		
		All	19,727,473.6			
	3	Between Groups	55,708.1	55,708.1	40.422	0.001***
		Within Groups	19,671,765.5	1,378.2		
		All	19,727,473.6			
	4	Between Groups	62,150.2	62,150.2	45.112	0.001***
		Within Groups	19,665,323.3	1,377.7		
		All	19,727,473.6			
	5	Between Groups	54,613.0	54,613.0	39.625	0.001***
		Within Groups	19,672,860.6	1,378.2		
		All	19,727,473.6			
SH Main Board	1	Between Groups	54,613.0	54,613.0	39.625	0.001***
		Within Groups	19,672,860.6	1,378.2		
		All	19,727,473.6			
	2	Between Groups	32,540.4	32,540.4	13.622	0.001***
		Within Groups	13,821,676.2	2,388.8		
		All	13,854,216.6			
	3	Between Groups	24,565.8	24,565.8	10.278	0.001***
		Within Groups	13,829,650.8	2,390.2		
		All	13,854,216.6			
	4	Between Groups	33,816.9	33,816.9	14.158	0.001***
		Within Groups	13,820,399.7	2,388.6		
		All	13,854,216.6			
	5	Between Groups	29,223.6	29,223.6	12.231	0.001***
		Within Groups	13,824,993.0	2,389.4		
		All	13,854,216.6			
SZ Main Board	1	Between Groups	20,273.6	20,273.6	27.087	0.001***
		Within Groups	1,366,696.2	748.5		
		All	1,386,969.8			

Stock Board	Patent Interval	Groups (n) & (y)	Stock Price Sum Square	Mean Square	F	p
	2	Between Groups	14,036.1	14,036.1	18.668	0.001***
		Within Groups	1,372,933.7	751.9		
		All	1,386,969.8			
	3	Between Groups	14,377.6	14,377.6	19.127	0.001***
		Within Groups	1,372,592.2	751.7		
		All	1,386,969.8			
	4	Between Groups	11,657.9	11,657.9	15.478	0.001***
		Within Groups	1,375,311.9	753.2		
		All	1,386,969.8			
	5	Between Groups	9,338.4	9,338.4	12.378	0.001***
		Within Groups	1,377,631.5	754.5		
		All	1,386,969.8			
GE Board	1	Between Groups	8,390.4	8,390.4	8.127	0.004**
		Within Groups	3,066,093.7	1,032.4		
		All	3,074,484.1			
	2	Between Groups	1,653.1	1,653.1	1.598	0.206
		Within Groups	3,072,830.9	1,034.6		
		All	3,074,484.1			
	3	Between Groups	194.9	194.9	0.188	0.664
		Within Groups	3,074,289.2	1,035.1		
		All	3,074,484.1			
	4	Between Groups	194.9	194.9	0.188	0.664
		Within Groups	3,074,289.2	1,035.1		
		All	3,074,484.1			
	5	Between Groups	6.3	6.3	0.006	0.938
		Within Groups	3,074,477.8	1,035.2		
		All	3,074,484.1			
SME Board	1	Between Groups	9,292.8	9,292.8	27.582	0.001***
		Within Groups	1,241,865.4	336.9		
		All	1,251,158.2			
	2	Between Groups	3,513.1	3,513.1	10.379	0.001***
		Within Groups	1,247,645.0	338.5		
		All	1,251,158.2			
	3	Between Groups	2,560.6	2,560.6	7.559	0.006**
		Within Groups	1,248,597.6	338.7		
		All	1,251,158.2			
	4	Between Groups	2,625.4	2,625.4	7.751	0.005**
		Within Groups	1,248,532.8	338.7		
		All	1,251,158.2			
	5	Between Groups	3,304.6	3,304.6	9.761	0.002**
		Within Groups	1,247,853.6	338.5		
		All	1,251,158.2			

p*<0.05, p**≤0.01, p***≤0.001

With regard to patent species of the invention publication, the design grant and the invention grant, the A-shares with new patents of patent interval of one year have significantly higher stock price means than those A-shares without patents for the whole stock market and all stock boards. The next question is what patent species that the A-shares have would effect the higher stock price.

Four patent species groups are therefore formed by the A-shares having at least one new patent of the invention publication, the utility model grant, the design grant and the invention grant respectively according to patent interval of one year. If an A-share has more than two species of new patents, for example, a new patent of the invention publication and a new patent of design grant, the A-share is specified to not only the invention publication group but also the design grant group. Table 8 shows the stock price variances between four patent species groups in the whole stock market and four stock board.

Table 8: ANOVA on Stock Price between Four Patent Species

Stock Board	Patent Species	Stock Price Sum Square	Mean Square	F	p
Whole Stock Market	Between Groups	36,807.5	12,269.2	6.320	0.001***
	Within Groups	65,314,804.5	1,941.4		
	All	65,351,611.9			
SH Main Board	Between Groups	31,490.1	10,496.7	2.743	0.042*

Stock Board	Patent Species	Stock Price			
		Sum Square	Mean Square	F	p
	Within Groups	48,411,947.3	3,826.1		
	All	48,443,437.4			
SZ Main Board	Between Groups	16,195.9	5,398.6	4.767	0.003**
	Within Groups	4,090,363.6	1,132.4		
	All	4,106,559.4			
GE Board	Between Groups	5,747.6	1,915.9	1.696	0.166
	Within Groups	8,853,308.6	1,129.8		
	All	8,859,056.2			
SME Board	Between Groups	2,391.2	797.1	2.079	0.101
	Within Groups	3,654,866.9	383.5		
	All	3,657,258.0			

p*<0.05, p**≤0.01, p***≤0.001

In Table 8, the stock price variances between four patent species are of significance in the whole stock market, SH main board and SZ main board; while the variances in GE board and SME board are not of significance. The A-shares of different patent species have significantly different stock price means in the whole stock market, SH main board and SZ main board.

Table 9 further shows the multiple comparisons of ANOVA on patent species in the whole stock market, SH main board and SZ main board.

With regard to the whole stock market, the stock price variances between the invention publication group and the design grant group, between the utility model grant group and the design grant group, between the utility model grant group and the invention grant group, are of significance; while the other variances are not of significance. According to the significant mean differences, the design grant group has the highest stock price mean while the utility model grant has the lowest stock price mean.

With regard to SH main board, the stock price variances between the invention publication group and the design grant group, between the utility model grant group and the design grant group, are of significance; while the other variances are not of significance. According to the significant mean differences, the design grant group has higher stock price mean than either the invention publication group or the utility model grant group. However, it cannot tell whether the design grant group has higher stock price mean than the invention grant group because the mean difference between the design grant group and the invention grant group is not of significance. while the utility model grant has the lowest stock price mean.

With regard to SZ main board, the stock price variances between the invention publication group and the design grant group, between the utility model grant group and the design grant group, between the design group and the invention grant group, are of significance; while the other variances are not of significance. According to the significant mean differences, the design grant group has the highest stock price mean while the utility model grant group has the lowest stock price mean.

Table 9: Multiple Comparisons of ANOVA on Stock Price between Patent Species

Stock Board	Patent Species		Stock Price (RMB)		
	(I) Group	(J) Group	Mean Diff.(I-J)	Std. Error	p
Whole Stock Market	Invention Publication	Utility Model Grant	1.062	0.616	0.085
	Invention Publication	Design Grant	-2.180	0.766	0.004**
	Invention Publication	Invention Grant	-0.628	0.647	0.331
	Utility Model Grant	Design Grant	-3.242	0.771	0.001***
	Utility Model Grant	Invention Grant	-1.691	0.653	0.010*
	Design Grant	Invention Grant	1.552	0.796	0.051
SH Main Board	Invention Publication	Utility Model Grant	1.060	1.403	0.450
	Invention Publication	Design Grant	-3.922	1.749	0.025*
	Invention Publication	Invention Grant	-0.468	1.491	0.754
	Utility Model Grant	Design Grant	-4.982	1.758	0.005**
	Utility Model Grant	Invention Grant	-1.528	1.501	0.309
	Design Grant	Invention Grant	3.454	1.828	0.059
SZ Main Board	Invention Publication	Utility Model Grant	1.724	1.427	0.227
	Invention Publication	Design Grant	-5.036	1.816	0.006**
	Invention Publication	Invention Grant	-1.027	1.510	0.497
	Utility Model Grant	Design Grant	-6.760	1.818	0.001***
	Utility Model Grant	Invention Grant	-2.751	1.512	0.069
	Design Grant	Invention Grant	4.009	1.884	0.033*

p*<0.05, p**≤0.01, p***≤0.001

In order to find out whether the A-shares of new patents of several patent species have higher stock price mean or not, three additional groups are formed and compared with the design grant group which having the highest stock price mean among four patent species. Three additional groups based on patent interval of one year are defined as below.

Group E: The A-shares having both design grants and invention publications;

Group F: The A-shares having both design grants and invention grants;

Group G: The A-shares having design grants, invention publications and invention grants.

Table 10 shows the result of ANOVA on the stock price between the design grant group and the additional groups including group E, group F and group G. The stock price variances between groups are not of significance no matter in the whole stock market or in any of four stock boards. It means that the A-shares having new patents of several patent species do not show higher stock price mean than the A-shares having new patents of one species.

Table 10: ANOVA on Stock Price between Additional Groups and Design Grant

Stock Board	Patent Species	Stock Price			
		Sum Square	Mean Square	F	p
Whole Stock Market	Between Groups	4,525.8	1,508.6	0.464	0.707
	Within Groups	54,184,381.1	3,247.9		
	All	54,188,906.9			
SH Main Board	Between Groups	4,866.5	1,622.2	0.224	0.880
	Within Groups	44,673,623.1	7,249.9		
	All	44,678,489.6			
SZ Main Board	Between Groups	853.8	284.6	0.136	0.938
	Within Groups	3,633,109.6	2,089.2		
	All	3,633,963.4			
GE Board	Between Groups	25.9	8.6	0.009	0.999
	Within Groups	3,883,391.6	1,002.4		
	All	3,883,417.6			
SME Board	Between Groups	955.6	318.5	0.845	0.469
	Within Groups	1,846,358.5	377.1		
	All	1,847,314.1			

p*<0.05, p**≤0.01, p***≤0.001

5. Conclusion

It was the first time to systematically discover the patent effects of different patent species on the stock price all over China stock market and four stock boards thereof. The following conclusions were arrived:

(1) With regard to the whole stock market, the A-shares having new patents of any patent species of the invention publication, the invention grant and the design grant by patent intervals from one year to five years shown the higher stock price mean than those A-shares having no new patents. The A-shares having new utility model grants by patent interval of one year shown the higher stock price mean than those A-shares having no new utility model grants.

(2) With regard to SH main board, the A-shares having new patents of any patent species of the invention publication, the invention grant and the design grant by patent intervals from one year to five years shown the higher stock price mean than those A-shares having no new patents. The A-shares having new utility model grants by patent intervals of one year and two years shown the higher stock price mean than those A-shares having no new utility model grants.

(3) With regard to SZ main board, the A-shares having new patents of any patent species of the invention publication, the invention grant and the design grant by patent intervals from one year to five years shown the higher stock price mean than those A-shares having no new patents. The A-shares having new utility model grants by patent intervals of four years and five years shown the higher stock price mean than those A-shares having no new utility model grants.

(4) With regard to GE board, the A-shares having new invention publications no matter what patent interval was did not show significantly different stock price mean from those A-shares having no new invention publications. The A-shares having new utility model grants by patent intervals from one year to five years shown the higher stock price mean than those A-shares having no new utility model grants. The A-shares having new design grants by patent intervals from three years to five years shown the higher stock price mean than those A-shares having no new design grants. The A-shares having new invention grants by patent interval of one year shown the higher stock price mean than those A-shares having no new invention grants.

(5) With regard to SME board, the A-shares having new patents of any patent species of the invention publication, the invention grant and the design grant by patent intervals from one year to

five years shown the higher stock price mean than those A-shares having no new patents. The A-shares having new utility model grants by patent interval of one year shown the higher stock price mean than those A-shares having no new utility model grants.

(6) With regard to patent species, the A-shares having new patents of the design grant shown significantly highest stock price mean while the A-shares having new patents of the utility model grant shown significantly lowest stock price mean in the whole stock market, SH main board and SZ main board. However, the A-shares having new patents of different patent species did not show significantly different stock price means in GE board and SME board.

(7) Though the invention grant was usually regarded to be more valuable than the invention publication, the A-shares having new patents of the invention grant did not show significantly higher stock price mean than those A-shares having new patents of the invention publication.

(8) The design grant in China was always regarded as the most valueless patent species, however, the China stock market gave a diverse result. Beyond the expectation, the A-shares having new patents of the design grant shown higher stock price mean than the A-shares having new patents of either the invention publication or the utility model grant, while the stock price variance between the A-shares of design grant and the A-shares of invention grant was not of significance.

The finding of this research gave a novel insight into China A-share's innovation outcome. It would improve the art of patent valuation and the listed company evaluation.

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