Innovation Continuity as Indicator for Observing Stock Return Rate in China Stock Market

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Abstract

Based on the patent data and stock return rates of thousands of China listed companies (A-shares), the effect of the innovation continuity which representing by the patent publication frequency, on the stock return rate were analyzed via ANOVA. The innovation continuity was good for observing the stock return rate in the whole market, Shanghai main board and small-medium board. The A-shares with the stronger innovation continuity showed the higher stock return rate. The utility model grant's innovation continuity was an indicator of the highest applicability. It could be applied for the whole market and any stock board. The design grant's strongest innovation continuity group had the highest stock return rate mean among all patent species' strongest innovation continuity groups 5 though the design grant was usually regarded as the most valueless patent species in China. The invention grant was always regarded as the most valuable patent species around the world, yet the stock return rate variance between the strongest innovation continuity groups of the invention grant and the invention publication was not significantly different. The invention publication's innovation continuity was more recommended rather than the invention grant's innovation continuity.

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1. Introduction

Innovation is an essential driver of economic progress that benefits consumers, 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 in the stock market catch more attention than those of unlisted companies and individuals.

For China patent and stock market, earlier research suggested that China patent statistics are meaningful indicators because China patent count is correlated with R&D input and financial output (Dang and Motohashi, 2015 [1]). It was found difficulty in integrating Chinese patent data with company data, however, the China patent database of all China listed companies and their subsidiaries from 1990 to 2010 was first time constructed (He, Tong, Zhang and He, 2016 [2]). By using the stock price data and patent data from 2011 to 2017 of China listed companies of RMB common stocks (A-shares) in Shanghai main board (SH main board), the patent indicators' leading effect on the stock price was proved (Chen, Wei and Che, 2018 [3]).

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). Via the patent indicators of ten years' patent data and the financial data of China A-shares from 2016Q4 to 2018Q3, the patent prediction equations for predicting 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) over the whole stock market and each stock board were proposed and showed the excellence on the investment (Chiu, Chen and Che, 2020 [4, 5, 6, 7, 8, 9]; Li, Deng and Che, 2020 [11, 12]; Chiu, Chen and Che, 2021 [10]; Li, Deng and Che, 2021 [13]). It was further found that China A-shares having new patents of any patent species shown the higher stock price mean and the higher stock return rate mean than those A-shares having no new patents (Tsai, Che and Bai, 2021 [14])

Patent is the outcome of company's R&D, the patent growth rate was proposed as the company's commitment to R&D (Deng, Lev and Narin, 1999 [15]; Thomas, 2001 [16]). However, the significant relationship of the patent growth and company's financial performance has not be established. By modifying the patent growth rate, the innovation continuity is proposed in this research as the continuous patent publication behaviour. It is the objective of this research to find out whether the innovation continuity of any patent species has significant effect on the stock return rate of China A-shares or not.

2. Methodology

2.1 Patent Species

There are four 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 passing both the preliminary examination and the substantial examination is always regarded as the most valuable. The other three patent species just need to pass the preliminary examination, wherein, the design grant is usually regarded as the most valueless patent species. After a patent is granted, the annual fee must be paid to the government regularly to maintain its validity. The valid patents are therefore regarded as more important than the invalid patents. In this research, the valid China patent of each A-share over previous five years by the end of each quarter from 2020Q1 to 2020Q4 are observed and discussed.

2.2 Population and Sample

The population comprises China A-shares listed in four stock boards including SH main board, SZ main board, GE board, and SME board. An effective sample must meet two conditions:

1. It is listed and has the exact closing price at the last trading day of each quarter from 2019 to 2020; and
2. It has at least one patent published over previous five years by the end of each quarter in 2020.

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 observation.

For avoiding the survivor bias, the annual stock return rates at the last trading day of four quarters in 2020 are calculated. For 2020Q1, the stock return rate of each A-share is calculated by the closing prices of the last trading day of 2019Q1 and 2020Q1. For 2020Q2, the stock return rate of each A-share is calculated by the closing prices of the last trading day of 2019Q2 and 2020Q3. And so forth for 2020Q3 and 2020Q4.

For discussing the innovation continuity, the annual publication frequency of patents is more concerned than either the amount of patents or the patent growth date. Therefore, five groups of innovation continuity are defined in this research. The group 1 consists of the A-shares having patent(s) published in only one year over previous five years by the end of each quarter in 2020; The group 2 consists of the A-shares having patents published in two different years over previous five years by the end of each quarter in 2020; the groups 3, 4, 5 and so forth. Hence, the group 1 is of the weakest innovation continuity while the group 5 is of the strongest innovation continuity.

2.3 Analysis of Variance (ANOVA)

Analysis of Variance (ANOVA) is applied for discovering whether the innovation

continuity good for observing the stock 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".

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

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 H0: $\mu 1 = \mu 2 = ... = \mu k$ is supported or rejected. If there is a significant difference between the groups, the null hypothesis is not supported, and the F-ratio will be larger and the corresponding p value is smaller than 0.05.

3. Results and Analysis

Table 1 shows the number of effective samples comprised in each innovation continuity group over the stock boards and four patent species, wherein, the whole market consists of all effective samples in four stock boards. Regarding the invention publication, the invention grant, and the utility model grant, the groups 5 have the most numbers of effective samples no matter what stock board and have a proportion around 50% or so of all effective samples. Regarding the design grant, the group 1 has the most number of effective samples. The A-shares showing stronger innovation continuity are much more than those A-shares having weaker innovation continuity.

Table 1: Effective Samples of Innovation Continuity Groups

Patent Species	Stock Board	Effective Samples				
		Group 1	Group 2	Group 3	Group 4	Group 5
Invention Publication	Whole Market	1206	1337	1387	2070	6353
	SH Main Board	569	597	545	765	2243
	SZ Main Board	181	182	157	178	698
	GE Board	213	267	343	582	1481
	SME Board	243	291	342	545	1931
Invention Grant	Whole Market	1536	1439	1565	1978	5148
	SH Main Board	671	604	579	689	1810
	SZ Main Board	206	160	146	151	605
	GE Board	297	301	425	587	1183
	SME Board	362	374	415	551	1550
Utility Model Grant	Whole Market	1354	1176	1292	1830	6248
	SH Main Board	627	479	528	742	2219
	SZ Main Board	223	152	130	150	718
	GE Board	290	258	296	453	1366
	SME Board	214	287	338	485	1945
Design Grant	Whole Market	2176	1369	1102	1068	1810
	SH Main Board	904	534	406	337	630
	SZ Main Board	271	162	100	109	244
	GE Board	443	334	288	285	345
	SME Board	558	339	308	337	591

3.1 Invention Publication

Table 2 shows the results of ANOVA on the stock return rate between the invention publication's innovation continuity groups. The stock return rate variances in the whole market and most stock boards reach $p^{***} \leq 0.001$ significance; different invention publication's innovation continuity groups have significantly different stock return rate means. However, the stock return rate variance in GE board is not of significance.

Table 2: Result of ANOVA on Stock Return Rate Between Invention Publication's Innovation Continuity Groups

Stock Board		Sum Square	Mean Square	F	p
Whole Market	between groups	168578.7	42144.7	15.930	0.001***
	within groups	32668262.0	2645.6		
	all	32836840.7			
SH Main Board	between groups	82057.6	20514.4	9.516	0.001***
	within groups	10161839.4	2155.7		
	all	10243897.0			
SZ Main Board	between groups	52769.9	13192.5	9.430	0.001***
	within groups	1946079.4	1399.1		
	all	1998849.4			
GE Board	between groups	13179.7	3294.9	0.874	0.479
	within groups	10865182.6	3771.3		
	all	10878362.3			
SME Board	between groups	104984.0	26246.0	9.538	0.001***
	within groups	9210127.0	2751.8		
	all	9315110.9			

$p^* < 0.05$, $p^{**} \leq 0.01$, $p^{***} \leq 0.001$

Table 3 shows the descriptive statistics of the stock return rates of five invention publication's innovation continuity groups. For the whole market and most stock boards except GE board, the groups 5 seem to have the higher stock return rate means than the other groups. For GE board, the group 1 seems to have the higher stock return rate mean.

Table 3:   Descriptive Statistics of Stock Return Rate of Invention Publication's Innovation Continuity Groups

Stock Board	Group	Stock Return Rate (%)		
		Mean	**Standard Deviation**	**Standard Error**
Whole Market	1	2.380	46.367	1.335
	2	6.224	48.172	1.317
	3	6.205	61.252	1.645
	4	7.714	51.611	1.134
	5	12.853	50.604	0.635
SH Main Board	1	-5.282	35.431	1.485
	2	4.835	44.294	1.813
	3	7.562	57.211	2.451
	4	6.488	49.392	1.786
	5	7.878	45.468	0.960
SZ Main Board	1	-0.970	38.356	2.851
	2	-3.257	36.598	2.713
	3	-8.952	29.636	2.365
	4	-3.905	34.979	2.622
	5	7.515	39.459	1.494
GE Board	1	21.241	57.985	3.973
	2	16.775	60.004	3.672
	3	17.519	87.381	4.718
	4	15.302	59.874	2.482
	5	20.262	55.144	1.433
SME Board	1	6.286	56.955	6.286
	2	5.324	48.541	5.324
	3	-0.347	41.082	-0.347
	4	5.127	48.613	5.127
	5	14.881	55.200	14.881

Table 4 shows the multiple comparisons of ANOVA on the stock return rate between every two invention publication's innovation continuity groups. Regarding the whole market, the stock return rate variances between groups 4 and 1, between groups 5 and 1, between groups 5 and 2, between groups 5 and 3, between groups 5 and 4, are of significance; the others are not. The group 5 is confirmed to have the highest stock return rate mean among all groups according to the significant mean differences. However, the stock return rate ranking of groups 1, 2, 3 and 4, is not provided with significance.

Regarding SH main board, the stock return rate variances between groups 2 and 1, between groups 3 and 1, between groups 4 and 1, between groups 5 and 1, are of significance; the others are not. The group 1 is therefore confirmed to have the

lowest stock return rate mean among all groups according to the significant mean differences. However, the stock return rate ranking of groups 2, 3, 4 and 5, is not provided with significance.

Regarding SZ main board, the stock return rate variances between groups 5 and 1, between groups 5 and 2, between groups 5 and 3, between groups 5 and 4, are of significance; the others are not. The group 5 is therefore confirmed to have the highest stock return rate mean among all groups according to the significant mean differences. However, the stock return rate ranking of groups 1, 2, 3 and 4, is not provided with significance.

Regarding GE board, as shown in Tables 2 and 4, the stock return rate variances between any two groups are not of significance. The stock return rates in groups 1, 2, 3, 4 and 5, do not show significant difference.

Regarding SME board, the stock return rate variances between groups 5 and 1, between groups 5 and 2, between groups 5 and 3, between groups 5 and 4, are of significance; the others are not. The group 5 is therefore confirmed to have the highest stock return rate mean among all groups according to the significant mean differences. However, the stock return rate ranking of groups 1, 2, 3 and 4, is not provided with significance.

According to the above analyses, the invention publication's innovation continuity is a good indicator for observing the stock return rate. The stock return rate variances between the invention publication's innovation continuity groups are of significance in the whole market and most stock boards except GE board. The innovation continuity group 5 has the highest stock return rate though the stock return rate ranking of the other innovation continuity groups is not significant.

Table 4: **Multiple Comparisons of ANOVA on Stock Return Rate between Invention Publication's Innovation Continuity Groups**

Stock Board	(I) Group	(J) Group	Stock Return Rate (%)		
			Mean Difference (I-J)	Standard Error	p
Whole Market	2	1	3.844	2.043	0.060
	3	1	3.825	2.025	0.059
	3	2	-0.019	1.971	0.992
	4	1	5.334	1.863	0.004**
	4	2	1.490	1.805	0.409
	4	3	1.509	1.785	0.398
	5	1	10.473	1.616	0.001***
	5	2	6.629	1.548	0.001***
	5	3	6.648	1.524	0.001***
	5	4	5.139	1.302	0.001***

SH Main Board	2	1	10.117	2.720	0.001***
	3	1	12.844	2.783	0.001***
	3	2	2.727	2.751	0.322
	4	1	11.770	2.570	0.001***
	4	2	1.653	2.535	0.515
	4	3	-1.074	2.603	0.680
	5	1	13.160	2.179	0.001***
	5	2	3.042	2.138	0.155
	5	3	0.315	2.217	0.887
	5	4	1.390	1.944	0.475
SZ Main Board	2	1	-2.287	3.926	0.560
	3	1	-7.982	4.079	0.051
	3	2	-5.695	4.074	0.162
	4	1	-2.935	3.948	0.457
	4	2	-0.648	3.943	0.870
	4	3	5.047	4.095	0.218
	5	1	8.485	3.120	0.007**
	5	2	10.772	3.113	0.001***
	5	3	16.467	3.304	0.001***
	5	4	11.420	3.141	0.001***
GE Board	2	1	-4.466	5.642	0.429
	3	1	-3.722	5.357	0.487
	3	2	0.744	5.012	0.882
	4	1	-5.939	4.918	0.227
	4	2	-1.473	4.539	0.746
	4	3	-2.217	4.180	0.596
	5	1	-0.978	4.500	0.828
	5	2	3.488	4.083	0.393
	5	3	2.743	3.680	0.456
	5	4	4.961	3.004	0.099
SME Board	2	1	-0.962	4.559	0.833
	3	1	-6.633	4.401	0.132
	3	2	-5.671	4.184	0.175
	4	1	-1.159	4.046	0.775
	4	2	-0.197	3.809	0.959
	4	3	5.474	3.619	0.130
	5	1	8.594	3.571	0.016*
	5	2	9.556	3.299	0.004**
	5	3	15.227	3.078	0.001***
	5	4	9.753	2.544	0.001***

$p* < 0.05$, $p** \leq 0.01$, $p*** \leq 0.001$

3.2 Invention Grant

Table 5 shows the results of ANOVA on the stock return rate between the invention grant's innovation continuity groups. The stock return rate variances reach $p^{***} \leq 0.001$ significance in the whole market, SZ main board, SME board, and $p < 0.05$ significance in SH main board. Different invention grant's innovation continuity groups have significantly different stock return rate means in the whole market and the aforementioned stock boards. However, the stock return rate variance in GE board is not of significance.

Table 5: Result of ANOVA on Stock Return Rate Between Invention Grant's Innovation Continuity Groups

Stock Board		Sum Square	Mean Square	F	p
Whole Market	between groups	83651.5	20912.9	7.705	0.001***
	within groups	31650880.7	2714.3		
	all	31734532.2			
SH Main Board	between groups	21897.5	5474.4	2.399	0.048*
	within groups	9923527.6	2282.3		
	all	9945425.1			
SZ Main Board	between groups	59282.9	14820.7	11.211	0.001***
	within groups	1669599.3	1321.9		
	all	1728882.2			
GE Board	between groups	24797.8	6199.4	1.638	0.162
	within groups	10550078.4	3784.1		
	all	10574876.2			
SME Board	between groups	94517.5	23629.4	8.529	0.001***
	within groups	8995239.2	2770.3		
	all	9089756.7			

$p^* < 0.05$, $p^{**} \leq 0.01$, $p^{***} \leq 0.001$

Table 6 shows the descriptive statistics of the stock return rates of five invention grant's innovation continuity groups. For the whole market, SZ main board and SME board, the groups 5 seem to have the higher stock return rate means than the other groups; whereas the groups 5 in SH main board and GE board do not.

Table 6: Descriptive Statistics of Stock Return Rate of Invention Grant's Innovation Continuity Groups

Stock Board	Group	Stock Return Rate (%)		
		Mean	Standard Deviation	Standard Error
Whole Market	1	7.723	53.036	1.353
	2	6.168	58.975	1.555
	3	7.884	49.117	1.242
	4	8.998	50.597	1.138
	5	12.978	51.209	0.714
SH Main Board	1	5.660	52.594	2.030
	2	3.056	47.423	1.930
	3	8.654	53.249	2.213
	4	3.619	42.483	1.618
	5	8.299	46.034	1.082
SZ Main Board	1	-7.363	27.062	1.886
	2	-8.871	30.255	2.392
	3	-4.833	32.334	2.676
	4	4.797	41.121	3.346
	5	7.050	40.047	1.628
GE Board	1	22.544	59.528	3.454
	2	24.636	94.626	5.454
	3	13.761	47.695	2.314
	4	19.069	62.340	2.573
	5	19.121	54.981	1.599
SME Board	1	7.972	56.450	2.967
	2	2.766	42.211	2.183
	3	5.266	48.571	2.384
	4	6.148	46.749	1.992
	5	16.068	56.824	1.443

Table 7 shows the multiple comparisons of ANOVA on the stock return rate between every two invention grant's innovation continuity groups. Regarding the whole market, the stock return rate variances between groups 5 and 1, between groups 5 and 2, between groups 5 and 3, between groups 5 and 4, are of significance; the others are not. The group 5 is confirmed to have the highest stock return rate mean among all groups according to the significant mean differences. However, the stock return rate ranking of groups 1, 2, 3 and 4, is not provided with significance. Regarding SH main board, the stock return rate variances between groups 5 and 2, between groups 5 and 4, are of significance; the others are not. The group 5 is confirmed to have the higher but not the highest stock return rate mean among all

groups according to the significant mean differences. In addition, the stock return rate ranking of groups 1, 2, 3 and 4, is not provided with significance..

Regarding SZ main board, the stock return rate variances between groups 4 and 1, between groups 4 and 2, between groups 4 and 3, between groups 5 and 1, between groups 5 and 2, between groups 5 and 3, are of significance; the others are not. The groups 4 and 5 are confirmed to have the higher stock return rate mean among all groups according to the significant mean differences. However, the stock return rate ranking of groups 1, 2, 3 and in groups 4, 5, is not provided with significance.

Regarding GE board, as shown in Tables 2 and 4, the stock return rate variance is only of significance between groups 3 and 2; the stock return rate variances between any other two groups are not of significance. The stock return rates in groups 1, 2, 3, 4 and 5, do not show significant difference.

Regarding SME board, the stock return rate variances between groups 5 and 1, between groups 5 and 2, between groups 5 and 3, between groups 5 and 4, are of significance; the others are not. The group 5 is therefore confirmed to have the highest stock return rate mean among all groups according to the significant mean differences. However, the stock return rate ranking of groups 1, 2, 3 and 4, is not provided with significance.

According to the above analyses, the invention grant's innovation continuity is a good indicator for observing the stock return rate in the whole market, SZ main board and SME board. The invention grant's innovation continuity group 5 has the higher stock return rate in the whole market, SZ main board and SME board, however, the stock return rate ranking of the other innovation continuity groups is not significant.

Table 7: Multiple Comparisons of ANOVA on Stock Return Rate between Invention Grant's Innovation Continuity Groups

Stock Board	(I) Group	(J) Group	Stock Return Rate (%)		
			Mean Difference (I-J)	Standard Error	p
Whole Market	2	1	-1.555	1.911	0.416
	3	1	0.161	1.871	0.931
	3	2	1.716	1.903	0.367
	4	1	1.275	1.772	0.472
	4	2	2.830	1.805	0.117
	4	3	1.114	1.763	0.527
	5	1	5.255	1.515	0.001***
	5	2	6.810	1.554	0.001***
	5	3	5.094	1.504	0.001***
	5	4	3.980	1.378	0.004**

SH Main Board	2	1	-2.604	2.680	0.331
	3	1	2.993	2.710	0.269
	3	2	5.598	2.779	0.044
	4	1	-2.041	2.591	0.431
	4	2	0.563	2.663	0.832
	4	3	-5.034	2.693	0.062
	5	1	2.639	2.159	0.222
	5	2	5.243	2.245	0.020*
	5	3	-0.354	2.281	0.877
	5	4	4.680	2.139	0.029*
SZ Main Board	2	1	-1.508	3.831	0.694
	3	1	2.530	3.933	0.520
	3	2	4.038	4.161	0.332
	4	1	12.160	3.895	0.002**
	4	2	13.668	4.125	0.001***
	4	3	9.630	4.220	0.023*
	5	1	14.413	2.933	0.001***
	5	2	15.921	3.232	0.001***
	5	3	11.883	3.353	0.001***
	5	4	2.253	3.307	0.496
GE Board	2	1	2.092	5.031	0.678
	3	1	-8.783	4.652	0.059
	3	2	-10.875	4.634	0.019*
	4	1	-3.475	4.380	0.428
	4	2	-5.568	4.361	0.202
	4	3	5.307	3.918	0.176
	5	1	-3.423	3.992	0.391
	5	2	-5.515	3.971	0.165
	5	3	5.360	3.479	0.124
	5	4	0.052	3.106	0.987
SME Board	2	1	-5.206	3.881	0.180
	3	1	-2.706	3.785	0.475
	3	2	2.500	3.753	0.505
	4	1	-1.824	3.561	0.608
	4	2	3.382	3.526	0.338
	4	3	0.881	3.421	0.797
	5	1	8.096	3.072	0.008**
	5	2	13.302	3.032	0.001***
	5	3	10.801	2.909	0.001***
	5	4	9.920	2.611	0.001***

$p* < 0.05$, $p** \leq 0.01$, $p*** \leq 0.001$

3.3 Utility Model Grant

Table 8 shows the results of ANOVA on the stock return rate between the utility model grant's innovation continuity groups. The stock return rate variances reach $p^{***} \leq 0.001$ significance in the whole market, SH main board, GE board, SME board, and $p^{**} \leq 0.01$ significance in SZ main board. Different utility model grant's innovation continuity groups have significantly different stock return rate means.

Table 8: Result of ANOVA on Stock Return Rate Between Utility Model Grant's Innovation Continuity Groups

Stock Board		Sum Square	Mean Square	F	p
Whole Market	between groups	72408.7	18102.2	6.466	0.001***
	within groups	33300338.7	2799.5		
	all	33372747.4			
SH Main Board	between groups	45679.1	11419.8	5.313	0.001***
	within groups	9865657.3	2149.4		
	all	9911336.4			
SZ Main Board	between groups	22025.6	5506.4	3.750	0.005**
	within groups	2008898.2	1468.5		
	all	2030923.8			
GE Board	between groups	90708.9	22677.2	4.988	0.001***
	within groups	12084746.9	4546.6		
	all	12175455.7			
SME Board	between groups	67100.9	16775.2	6.252	0.001***
	within groups	8757492.3	2683.1		
	all	8824593.2			

$p^* < 0.05$, $p^{**} \leq 0.01$, $p^{***} \leq 0.001$

Table 9 shows the descriptive statistics of the stock return rates of five utility model grant's innovation continuity groups. For the whole market, SH main board and GE board, the groups 3 seem to have the higher stock return rate means than the other groups. For SZ main board and SME board, the groups 5 seem to have the higher stock return rate means than the other groups.

Table 9: Descriptive Statistics of Stock Return Rate of Utility Model Grant's Innovation Continuity Groups

Stock Board	Group	Stock Price Return Rate (%)		
		Mean	Standard Deviation	Standard Error
Whole Market	1	3.009	45.676	1.241
	2	7.896	59.596	1.738
	3	11.954	68.041	1.893
	4	7.792	53.372	1.248
	5	10.163	49.193	0.622
SH Main Board	1	-2.870	37.907	1.514
	2	4.946	52.937	2.419
	3	7.100	50.387	2.193
	4	6.761	47.100	1.729
	5	6.004	45.762	0.971
SZ Main Board	1	2.465	44.036	2.949
	2	1.401	37.873	3.072
	3	-6.525	32.589	2.858
	4	-5.476	29.507	2.409
	5	4.434	39.081	1.458
GE Board	1	17.060	55.893	3.282
	2	24.075	85.972	5.352
	3	34.444	105.674	6.142
	4	17.551	73.274	3.443
	5	16.087	51.078	1.382
SME Board	1	1.760	48.959	3.347
	2	1.714	46.878	2.767
	3	6.949	54.271	2.952
	4	4.356	43.916	1.994
	5	12.864	54.113	1.227

Table 10 shows the multiple comparisons of ANOVA on the stock return rate between every two utility model grant's innovation continuity groups. Regarding the whole market, the stock return rate variances between groups 2 and 1, between groups 3 and 1, between groups 4 and 1, between groups 4 and 3, between groups 5 and 1, are of significance; the others are not. The group 1 is therefore confirmed to have the lowest stock return rate mean among all groups according to the significant mean differences. However, the stock return rate ranking of groups 2, 3, 4 and 5, is not provided with significance.

Regarding SH main board, the stock return rate variances between groups 2 and 1, between groups 3 and 1, between groups 4 and 1, between groups 5 and 1, are of significance; the others are not. The group 1 is therefore confirmed to have the

lowest stock return rate mean among all groups according to the significant mean differences. However, the stock return rate ranking of groups 2, 3, 4 and 5, is not provided with significance..

Regarding SZ main board, the stock return rate variances between groups 3 and 1, between groups 4 and 1, between groups 5 and 3, between groups 5 and 4, are of significance; the others are not. The group 5 are confirmed to have the highest stock return rate mean among all groups according to the significant mean differences. However, the stock return rate ranking of groups 1, 2, 3 and 4, is not provided with significance.

Regarding GE board, the stock return rate variances between groups 3 and 1, between groups 4 and 3, between groups 5 and 3, are of significance; the others are not. The group 3 is therefore confirmed to have the highest stock return rate mean among all groups according to the significant mean differences. However, the stock return rate ranking of groups 1, 2, 4 and 5, is not provided with significance.

Regarding SME board, the stock return rate variances between groups 5 and 1, between groups 5 and 2, between groups 5 and 4, are of significance; the others are not. The group 5 is therefore confirmed to have the highest stock return rate mean among all groups according to the significant mean differences. However, the stock return rate ranking of groups 1, 2, 3 and 4, is not provided with significance.

According to the above analyses, the utility model grant's innovation continuity shows its particular observing effect on the stock return rate. The innovation continuity group 1 has the lowest stock return rate in the whole market, SH main board and SME board. The innovation continuity group 5 has the highest stock return rate in SZ main board and SME board. The innovation continuity group 3 has the highest stock return rate in GE board.

Table 10: Multiple Comparison of ANOVA on Stock Return Rate between Utility Model Grant's Innovation Continuity Groups

Stock Board	(I) Group	(J) Group	Stock Return Rate (%)		
			Mean Difference (I-J)	Standard Error	p
Whole Market	2	1	4.886	2.109	0.021*
	3	1	8.945	2.058	0.001***
	3	2	4.059	2.132	0.057
	4	1	4.782	1.897	0.012*
	4	2	-0.104	1.977	0.958
	4	3	-4.163	1.923	0.030*
	5	1	7.154	1.586	0.001***
	5	2	2.268	1.682	0.178
	5	3	-1.791	1.617	0.268
	5	4	2.372	1.406	0.092

SH Main Board	2	1	7.815	2.813	0.005**
	3	1	9.970	2.738	0.001***
	3	2	2.155	2.925	0.461
	4	1	9.631	2.515	0.001***
	4	2	1.816	2.717	0.504
	4	3	-0.339	2.640	0.898
	5	1	8.874	2.097	0.001***
	5	2	1.058	2.336	0.650
	5	3	-1.096	2.245	0.625
	5	4	-0.757	1.966	0.700
SZ Main Board	2	1	-1.064	4.031	0.792
	3	1	-8.990	4.229	0.034*
	3	2	-7.926	4.578	0.084
	4	1	-7.941	4.047	0.050*
	4	2	-6.877	4.410	0.119
	4	3	1.049	4.592	0.819
	5	1	1.968	2.938	0.503
	5	2	3.032	3.421	0.376
	5	3	10.959	3.653	0.003**
	5	4	9.909	3.440	0.004*
GE Board	2	1	7.015	5.771	0.224
	3	1	17.385	5.571	0.002**
	3	2	10.370	5.743	0.071
	4	1	0.491	5.071	0.923
	4	2	-6.524	5.259	0.215
	4	3	-16.894	5.039	0.001***
	5	1	-0.973	4.360	0.823
	5	2	-7.988	4.577	0.081
	5	3	-18.357	4.323	0.001***
	5	4	-1.464	3.656	0.689
SME Board	2	1	-0.046	4.678	0.992
	3	1	5.188	4.525	0.252
	3	2	5.235	4.158	0.208
	4	1	2.596	4.251	0.541
	4	2	2.642	3.858	0.493
	4	3	-2.593	3.670	0.480
	5	1	11.103	3.731	0.003**
	5	2	11.149	3.275	0.001***
	5	3	5.915	3.052	0.053
	5	4	8.507	2.629	0.001***

$p* < 0.05$, $p** \leq 0.01$, $p*** \leq 0.001$

3.4 Design Grant

Table 11 shows the results of ANOVA on the stock return rate between the design grant's innovation continuity groups. The stock return rate variances in the whole market, SZ main board and SME board reach $p*** \leq 0.001$ significance, different design grant's innovation continuity groups have significantly different stock return rate means. However, the stock return rate variances in SH main board and GE board are not of significance.

Table 11: Result of ANOVA on Stock Return Rate Between Design Grant's Innovation Continuity Groups

Stock Board		Sum Square	Mean Square	F	p
Whole Market	between groups	122155.2	30538.8	11.304	0.001***
	within groups	20315232.1	2701.5		
	all	20437387.4			
SH Main Board	between groups	9777.9	2444.5	1.116	0.347
	within groups	6144862.0	2189.9		
	all	6154639.9			
SZ Main Board	between groups	73935.0	18483.7	11.570	0.001***
	within groups	1407482.9	1597.6		
	all	1481417.8			
GE Board	between groups	22031.6	5507.9	1.460	0.212
	within groups	6373558.9	3771.3		
	all	6395590.5			
SME Board	between groups	109326.6	27331.7	9.450	0.001***
	within groups	6154452.0	2892.1		
	all	6263778.6			

$p* < 0.05$, $p** \leq 0.01$, $p*** \leq 0.001$

Table 12 shows the descriptive statistics of the stock return rates of five design grant's innovation continuity groups. For the whole market and most stock boards except SH main board, the groups 5 seem to have the higher stock return rate means than the other groups. For SH main board, the group 4 seems to have the higher stock return rate mean.

Table 12: Descriptive Statistics of Stock Return Rate of Design Grant's Innovation Continuity Groups

Patent Species	Group	Stock Return Rate (%)		
		Mean	Standard Deviation	Standard Error
Whole Market	1	7.813	49.901	1.070
	2	5.159	45.332	1.225
	3	8.585	57.642	1.736
	4	10.981	50.445	1.544
	5	16.498	56.205	1.321
SH Main Board	1	6.056	47.971	1.595
	2	3.933	45.908	1.987
	3	5.261	41.527	2.061
	4	9.724	52.400	2.854
	5	8.263	45.854	1.827
SZ Main Board	1	-2.653	36.684	2.228
	2	-6.723	26.931	2.116
	3	3.879	43.399	4.340
	4	11.489	53.757	5.149
	5	16.362	42.008	2.689
GE Board	1	18.170	53.419	2.538
	2	15.121	55.295	3.026
	3	15.905	87.358	5.148
	4	10.120	48.655	2.882
	5	21.452	59.835	3.221
SME Board	1	7.521	54.151	2.292
	2	2.951	38.248	2.077
	3	7.649	42.737	2.435
	4	12.803	48.986	2.668
	5	22.441	67.142	2.762

Table 13 shows the multiple comparisons of ANOVA on the stock return rate between every two design grant's innovation continuity groups. Regarding the whole market, the stock return rate variances between groups 4 and 2, between groups 5 and 1, between groups 5 and 2, between groups 5 and 3, between groups 5 and 4, are of significance; the others are not. The group 5 is confirmed to have the highest stock return rate mean among all groups according to the significant mean differences. However, the stock return rate ranking of groups 1, 2, 3 and 4, is not provided with significance.

Regarding SH main board, as shown in Tables 11 and 13, the stock return rate variances between any two groups are not of significance. The stock return rates in groups 1, 2, 3, 4 and 5, do not show significant difference.

Regarding SZ main board, the stock return rate variances between groups 3 and 2, between groups 4 and 2, between groups 5 and 1, between groups 5 and 2, between groups 5 and 3, are of significance; the others are not. The groups 4 and 5 are therefore confirmed to have the higher stock return rate means among all groups according to the significant mean differences. However, the stock return rate ranking of groups 1, 2, and 3, is not provided with significance.

Regarding GE board, as shown in Tables 11 and 13, the stock return rate variance is only of significance between groups 5 and 4; whereas the stock return rate variances between any other two groups are not of significance.

Regarding SME board, the stock return rate variances between groups 4 and 2, groups 5 and 1, between groups 5 and 2, between groups 5 and 3, between groups 5 and 4, are of significance; the others are not. The group 5 is therefore confirmed to have the highest stock return rate mean among all groups according to the significant mean differences. However, the stock return rate ranking of groups 1, 2, 3 and 4, is not provided with significance.

According to the above analyses, the design grant's innovation continuity is a good indicator for observing the stock return rate in the whole market, SZ main board and SME board.

Table 13: Multiple Comparisons of ANOVA on Stock Return Rate between Design Grant's Innovation Continuity Groups

Stock Board	(I) Group	(J) Group	Stock Return Rate (%)		
			Mean Difference (I-J)	Standard Error	p
Whole Market	2	1	-2.655	1.793	0.139
	3	1	0.772	1.922	0.688
	3	2	3.426	2.104	0.103
	4	1	3.168	1.942	0.103
	4	2	5.823	2.122	0.006**
	4	3	2.396	2.232	0.283
	5	1	8.685	1.653	0.001***
	5	2	11.340	1.862	0.001***
	5	3	7.913	1.986	0.001***
	5	4	5.517	2.005	0.006**
SH Main Board	2	1	-2.123	2.554	0.406
	3	1	-0.794	2.796	0.776
	3	2	1.328	3.081	0.666
	4	1	3.668	2.987	0.220
	4	2	5.790	3.256	0.075
	4	3	4.462	3.448	0.196
	5	1	2.207	2.429	0.363
	5	2	4.330	2.753	0.116
	5	3	3.002	2.978	0.314
	5	4	-1.460	3.158	0.644

SZ Main Board	2	1	-4.071	3.969	0.305
	3	1	6.531	4.677	0.163
	3	2	10.602	5.083	0.037*
	4	1	14.141	4.533	0.002**
	4	2	18.212	4.952	0.001***
	4	3	7.610	5.535	0.169
	5	1	19.015	3.527	0.001***
	5	2	23.085	4.051	0.001***
	5	3	12.483	4.746	0.009**
	5	4	4.873	4.605	0.290
GE Board	2	1	-3.048	4.450	0.493
	3	1	-2.265	4.648	0.626
	3	2	0.783	4.938	0.874
	4	1	-8.050	4.663	0.084
	4	2	-5.002	4.952	0.313
	4	3	-5.785	5.131	0.260
	5	1	3.282	4.410	0.457
	5	2	6.330	4.714	0.180
	5	3	5.547	4.902	0.258
	5	4	11.332	4.916	0.021*
SME Board	2	1	-4.570	3.703	0.217
	3	1	0.127	3.817	0.973
	3	2	4.697	4.233	0.267
	4	1	5.281	3.710	0.155
	4	2	9.852	4.137	0.017*
	4	3	5.154	4.239	0.224
	5	1	14.920	3.174	0.001***
	5	2	19.490	3.664	0.001***
	5	3	14.792	3.779	0.001***
	5	4	9.638	3.671	0.009**

$p^* < 0.05$, $p^{**} \leq 0.01$, $p^{***} \leq 0.001$

3.5   Cross Comparison

Since the innovation continuity groups 5 of all patent species seem to have the higher stock return rates, Table 14 shows the results of ANOVA on the stock return rate between all patent species' innovation continuity groups 5 regarding the whole market. The stock return rate variance reaches $p^{***} \leq 0.001$ significance, different patent species' innovation continuity groups 5 have significantly different stock return rate means.

**Table 14: Result of ANOVA on Stock Return Rate Between Four Patent Species'
Innovation Continuity Groups 5**

	Sum Square	Mean Square	F	p
between groups	64655.9	21552.0	8.330	0.001***
within groups	50595738.4	2587.4		
all	50660394.3			

p*<0.05, p**≤0.01, p***≤0.001

Table 15 shows the descriptive statistics of the stock return rates of four patent
species' innovation continuity groups 5 regarding the whole market, wherein, the
groups 51, 52, 53, and 54 respectively represent the innovation continuity groups 5
of the invention publication, the invention grant, the utility model grant, and the
design grant. The group 53 of the utility model grant seems to have the lower stock
return rate and the group 54 the design grant seems to have the higher stock return
rate.

**Table 15: Descriptive Statistics of Stock Return Rate of Four Patent Species's
Innovation Continuity Groups 5**

Group	Effective Samples	Stock Price Return Rate (%)		
		Mean	Standard Deviation	Standard Error
51	6353	12.853	50.604	0.635
52	5148	12.978	51.209	0.714
53	6248	10.163	49.193	0.622
54	1810	16.498	56.205	1.321

Table 16 shows the multiple comparisons of ANOVA on the stock return rate
between every two innovation continuity groups 5 regarding the whole market. The
stock return rate variance is not of significance only between groups 52 and 51, the
other stock return rate variances are of significance. According to the significant
mean differences, the design grant's innovation continuity group 5 has the highest
stock return rate mean, the utility model grant's innovation continuity group 5 has
the lowest stock return rate. In addition, the innovation continuity groups 5 of the
invention publication and the invention grant do not have significantly different
stock return rates.

Table 16: Multiple Comparisons of ANOVA on Stock Return Rate between Four Patent Species's Innovation Continuity Groups 5

(I) Group	(J) Group	Stock Return Rate (%)		
		Mean Difference (I-J)	Standard Error	p
52	51	0.125	0.954	0.896
53	51	-2.690	0.906	0.003**
53	52	-2.815	0.957	0.003**
54	51	3.645	1.355	0.007*
54	52	3.520	1.390	0.011*
54	53	6.335	1.358	0.001***

p*<0.05, p**≤0.01, p***≤0.001

4. Conclusion and Recommendation

Four quarter's stock return rates in 2020 of China A-shares listed in four stock boards and the patent data of four patent species including the invention publication, the invention grant, the utility model grant, and the design grant, over previous five years were collected. The variances of the stock return rate via different innovation continuity which representing by the patent publication frequency over previous five years were analyzed via ANOVA. The following conclusions were arrived:

1.   Regarding the whole market, SZ main board and SME board, the innovation continuity of any patent species was a good indicator for observing the stock return rate. The A-shares with the stronger innovation continuity usually showed the higher stock return rate and the A-shares with the weaker innovation continuity usually showed the lower stock return rate. However, it was not appropriate to exactly rank the stock return rate by the innovation continuity because the ranking relationship is not provided with significance.

2.   Regarding SH main board, the innovation continuity of any of the invention publication, the invention grant, and the utility model grant was a good indicator for observing the stock return rate; whereas the innovation continuity of the design grant is not. The A-shares with the stronger innovation continuity usually showed the higher stock return rate. Regarding GE board, the innovation continuity of the utility model grant was a good indicator for observing the stock return rate; whereas the innovation continuity of any other patent species is not. The A-shares in SH board and GE board with the stronger innovation continuity of specific patent species usually showed the higher stock return rate. However, it was also not appropriate to exactly rank the stock return rate by the abovementioned innovation continuity because the ranking relationship is not provided with significance either.

3.   Considering the patent species, the innovation continuity of the utility model grant was the indicator of the highest applicability. It could be applied for the whole market and any stock board. However, the utility model grant's strongest innovation continuity group had the lowest stock return rate mean when comparing with the strongest innovation continuity groups of the other patent species.

4.   In addition, the design grant's strongest innovation continuity group had the

highest stock return rate mean among all patent species' strongest innovation continuity groups though the design grant was usually regarded as the most valueless patent species in China. The investors and the evaluation institutes were suggested to pay more attention on the design grant and the A-shares with design grant patents from now on.

5.   The invention grant was always regarded as the most valuable patent species around the world, yet the stock return rate variance between the strongest innovation continuity groups of the invention grant and the invention publication was not significantly different. In China, the invention grant has much longer examination duration which being calculated from the filing date to the issue date, the time lag was long. Since there was no significantly difference in the stock return rate variance between the strongest innovation continuity groups of the invention grant and the invention publication, the invention publication's innovation continuity was more recommended to apply for observation rather than the invention grant's innovation continuity.

The finding of this research would improve the state of the art in the patent valuation and the listed company evaluation.

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References

[1]   Dang, J. and Motohashi, K. (2015). Patent statistics: A good indicator for innovation in China? Patent subsidy program impacts on patent quality. China Economic Review, 35 (Sep), 2015, pp. 137-155. https://doi.org/10.1016/J.CHIECO.2015.03.012.

[2]   He, Z.L., Tong, T.W., Zhang, Y. and He, W. (2016).Constructing a Chinese patent database of listed firms in China: Descriptions, lessons, and insights. Journal of Economics & Management Strategy, 27(3), pp. 579 - 606. https://doi.org/10.1111/jems.12186.

[3]   Chen, T.M., Wei, C.C. and Che, H.C. (2018). Contribution of Patent Indicators to China Stock Performance. Proceedings of the IEEE 7th International Congress on Advanced Applied Informatics (ICAAI2018). Yonago, Japan, pp. 793 - 798.

[4]   Chiu, Y.J., Chen, K.C. and Che, H.C. (2020). Does Patent Help to Build Investment Portfolio of China A-Shares under China-US Trade Conflict?. Mathematical Problems in Engineering, ID 7317480, https://doi.org/10.1155/2020/7317480

[5]   Chiu, Y.J., Chen, K.C. and Che, H.C. (2020). Patent implemented time series algorithm for building stock portfolios in China A-Shares. Asian Journal of Information and Communications, 12(1), pp. 156 - 170.

[6]   Chiu, Y.J., Chen, K.C. and Che, H.C. (2020). Using Patent to Predict Book-Value-Per-Share and Investment -- Evidence in China A-Shares. International Journal of Innovation in Management, 8(2), pp. 47 - 64.

[7]   Chiu, Y.J., Chen, K.C. and Che, H.C. (2020). Patent As Predictive Indicator of Investment: An Empirical Study of China A-Shares. Proceedings of the 2020 Chinese Society for Management of Technology Conference, Hsinchu, Taiwan.

[8]   Chiu, Y.J., Chen, K.C. and Che, H.C. (2020). Patent Informatics in Predicting Stock Price and Increasing Investment Performance -- An Empirical Study of China Four Stock Boards. Proceedings of the 2020 International Conference on Economics, Management and Technology (IEMT2020), Kaohsiung, Taiwan.

[9]   Chiu, Y.J., Chen, K.C. and Che, H.C. (2020). Patent Informatics in Predicting Return-on-Assets (ROA) and Increasing Investment Performance in China. Proceedings of the 2020 International Conference on Business Administration - Fall Session (ICBA 2020 Fall), New Taipei City, Taiwan.

[10] Chiu, Y.J., Chen, K.C. and Che, H.C. (2021). Patent predictive price-to-book ratio (PB) on improving investment performance -- Evidence in China. World Patent Information, ID 102039. https://doi.org/10.1016/j.wpi.2021.102039

[11] Li, Z., Deng, G. and Che, H.C. (2020). Patent-Based Predictive ROE on Increasing Investment Performance of China Stock Market. Proceedings of the 2020 IEEE International Conference on Computer and Communications (ICCC2020), Chengdu, China.

[12] Li, Z., Deng, G. and Che, H.C. (2020). Patent-Based Predictive Price-to-Earnings on Increasing Investment Performance of China Stock Market. Proceedings of the 2020 International Symposium on Computational Intelligence and Design (ISCID2020), Hangzhou, China.

[13] Li, Z., Deng, G. and Che, H.C. (2021). Patent-Based Predictive EPS on Increasing Investment Performance of China Stock Market. Proceedings of the 2021 IEEE International Conference on Power Electronics, Computer Applications (ICPECA2021), Shenyang, China.

[14] Tsai, H.W., Che, H.C. and Bai, B. (2021). Patent Effects on Higher Stock Price and Higher Return Rate - A Study in China Stock Market. Proceedings of the International Conference on Innovation and Management (IAM2021), Taiwan.

[15] Deng, D., Lev, B. and Narin, F. (1999). Science and technology as predictors of stock performance. Financial Analysts Journal, 55(3), 1999, pp. 20 - 32.

[16] Thomas, P. (2001). A relationship between technology indicators and stock market performance. Scientometrics, 55(1), pp. 319 - 333.