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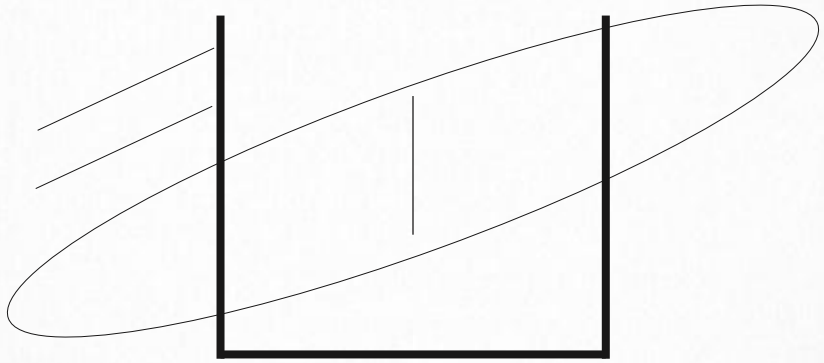
Patenting and stock returns of pharmaceutical companies: Evidence from the mainland of China, Hong Kong and USA



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Introduction

- As an essential science, technology, and innovation indicator, patents have been increasingly used to reflect the performance of corporates on stock markets over the last decades, especially in the innovation-driven high-technology industry.

- A few previous empirical studies point out the positive relationship between patent and market.

- On the contrary, some studies found that patent variables have virtually no influence on market value of firms.

- But, in this field, very few study focuses on pharmaceutical industry or China.

- Many people are interested about whether Chinese drug industry is driven by innovation, what roles patents play in this industry, and how about regional differences?

Ref: Griliches 1991, Guo 2013, De Carolis 2003, Chen and Chang 2010, Chang 2012, etc.

Introduction

This study aims to identify the impact of patents on financial performance of pharmaceutical firms listed in the United States and China.

- This is a longitudinal analysis based on the time-lag effects of patents on markets. It can inform researchers and investors of **early signals** of market changes and further support relevant decision-making.

- Besides, **cross-regional comparison** helps us to understand more about stock markets in different regions.

Samples

1 **SHSE**
Shanghai Stock Exchange

2 **SZSE**
Shenzhen Stock Exchange

3 **SEHK**
The Stock Exchange of Hong Kong

4 **NASDAQ**
National Association of Securities Dealers Automated Quotation

5 **NYSE**
The New York Stock Exchange

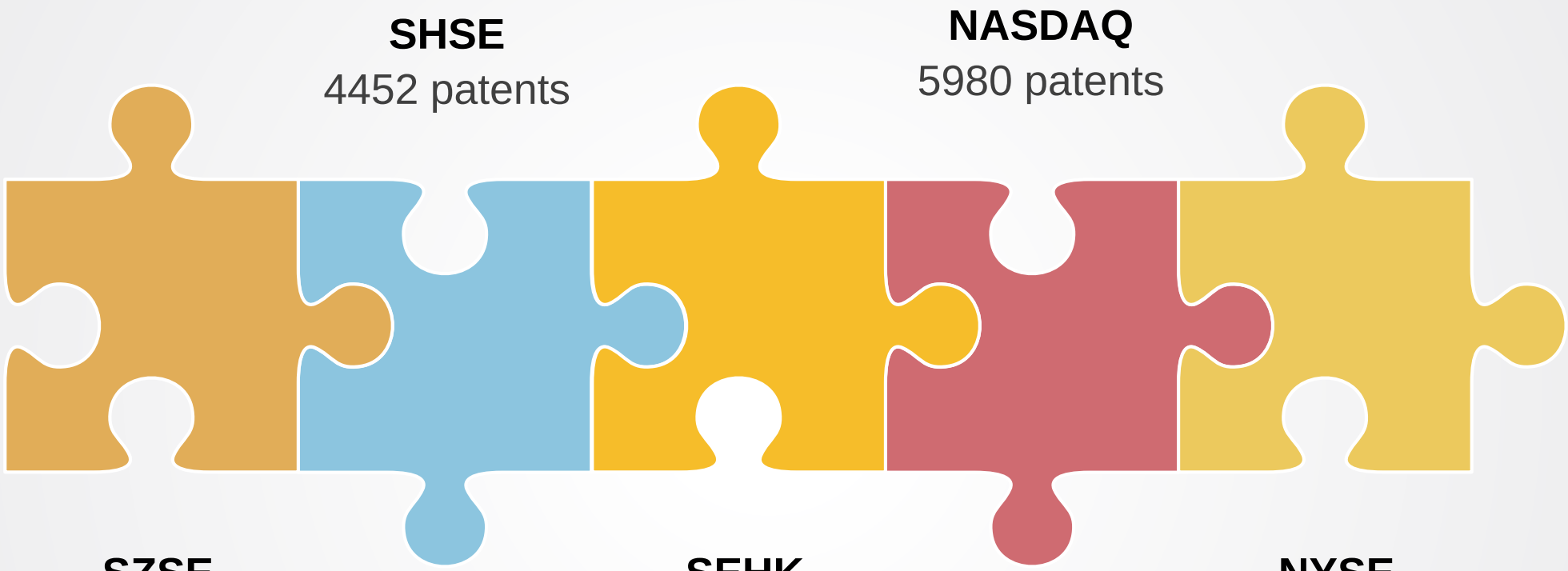
Stratified sampling: all pharmaceutical companies from different stock markets.

→ 5 companies

4 grades → 4×5=20 companies

5 stock markets → 5×20=100 companies

Patent data

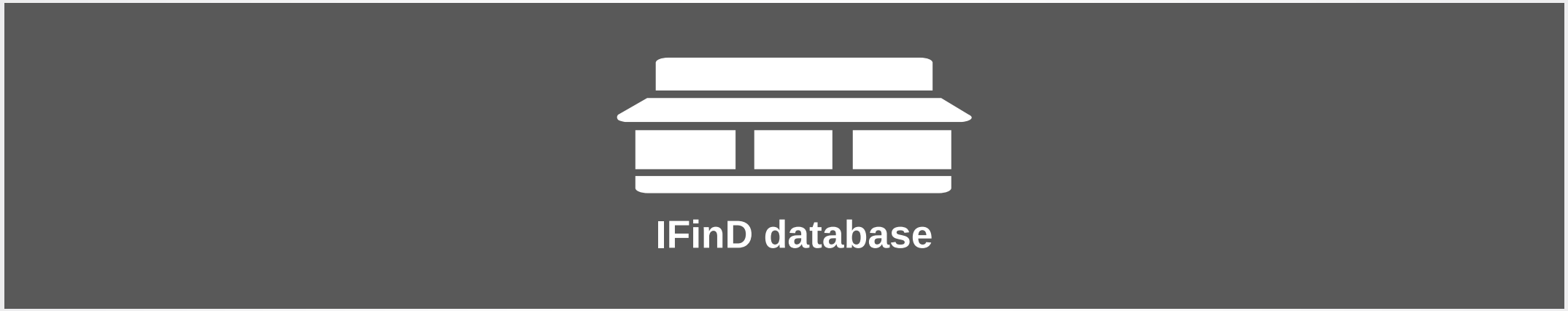


Indicators: AAP the number of annually added patents; ATP the number of annually total patents; IPC the number of IPC codes; Inventors the number of patent inventors; PCT the number of PCT patent applications; Chinese patents, U.S. patents, European patents represent the numbers of patents granted in China, in U.S., and in Europe.

Source : Online database of China National Intellectual Property Administration (CNIPA) & Derwent Innovation database

Financial data

2009 to 2017



Annual sales data and some other related financial data for the years **2009 to 2017** were extracted from the IFinD database of Hithink RoyalFlush Information Network.

Indicators: GS gross sales; GP gross profit; PEPS primary earnings per share; DEPS diluted earnings per share; GPM gross profit margin; NPM net profit margin; DSI days sales of inventory; DAR debt asset ratio; CR current ratio; and QR quick ratio.

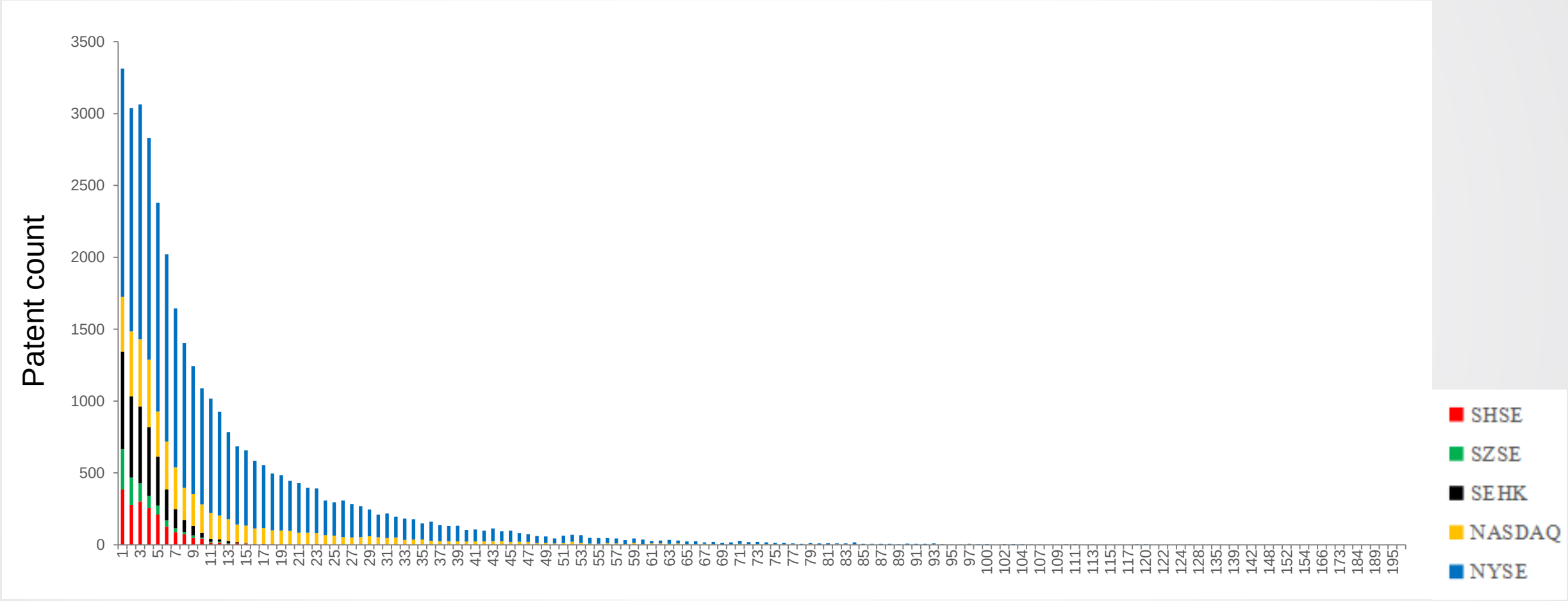
Statistical analyses

Univariate analysis	Mean, standard deviation, probability distribution, etc		
Bivariate analysis	Student t-test or Mann-Whitney U test	Pearson product-moment or Spearman rank-correlation coefficients	Shapiro-Wilk and Kolmogorov-Smirnov test for normality
GEE model	For the longitudinal analysis, a Generalized Estimating Equations (GEE) was applied because of the possible intra-class correlations and repeated measures.		
Lag model	financial indicator $_{i,t} = \beta_0 + \beta_1$ patent $_{i,t-n} + \beta_2$ firm size control $_{i,t} + \beta_3$ year control $_{i,t} + \varepsilon_{i,t}$ Where n=0 to 4 denotes lagged years, t=2009 to 2017, i represents drug company identifier, β_0 is the intercept, β_1, β_2, β_3 is regression coefficients, and ε represents error term.		

Descriptive statistics of the five stock markets

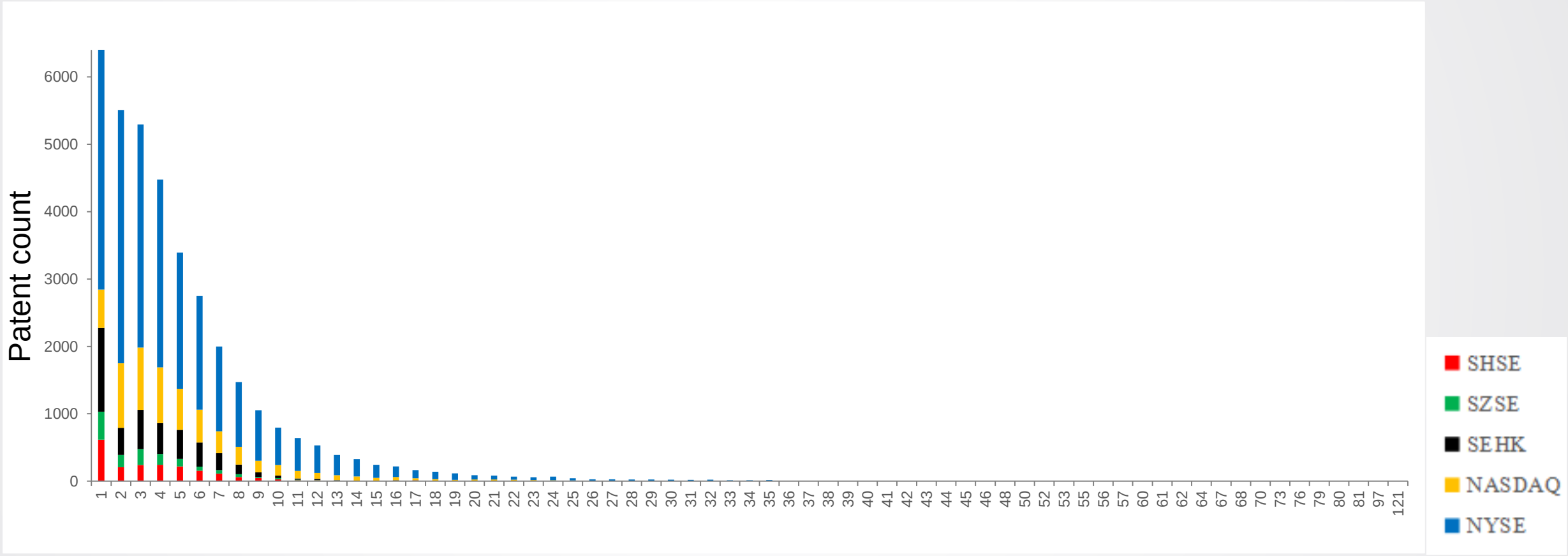
	Patent Counts	Patent granted year	Listing Year of drug companies	Firm size	Primary Earnings Per Share	Currency	Number of Companies	Pharmaceutical firms
SZSE	3504	2001-2018	1993-2015	9,688,226,994	0.5404	RMB	2127	133
SHSE	4452	2000-2018	1994-2018	15,622,865,672	0.6988	RMB	1489	56
SEHK	5790	1993-2018	1992-2017	8,141,667,273	0.3299	RMB	2303	69
NASDAQ	5980	1980-2018	1983-2015	25,102,210,000	2.8441	USD	3649	94
NYSE	22206	1964-2018	1962-2013	51,365,877,660	6.9554	USD	4501	26

Distribution for measurement variables



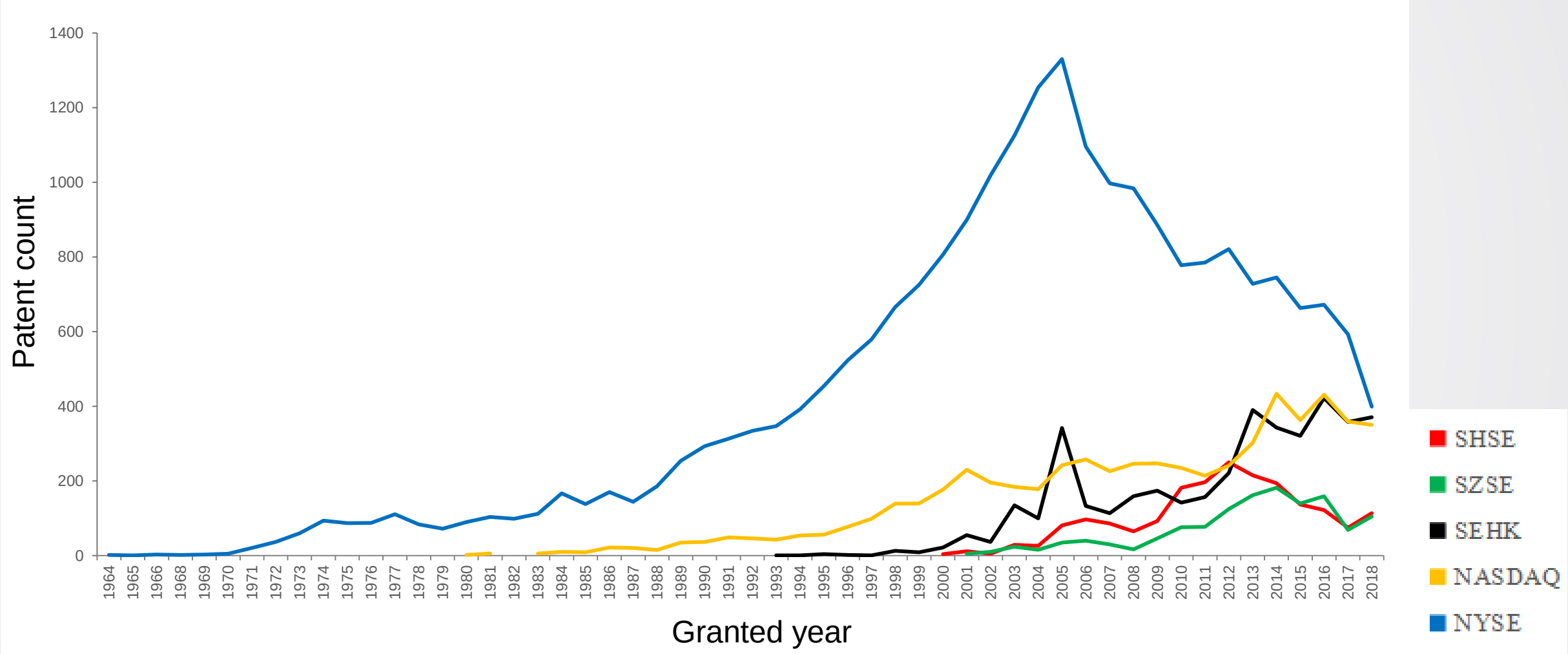
Number of IPCs in five stock markets

Distribution for measurement variables

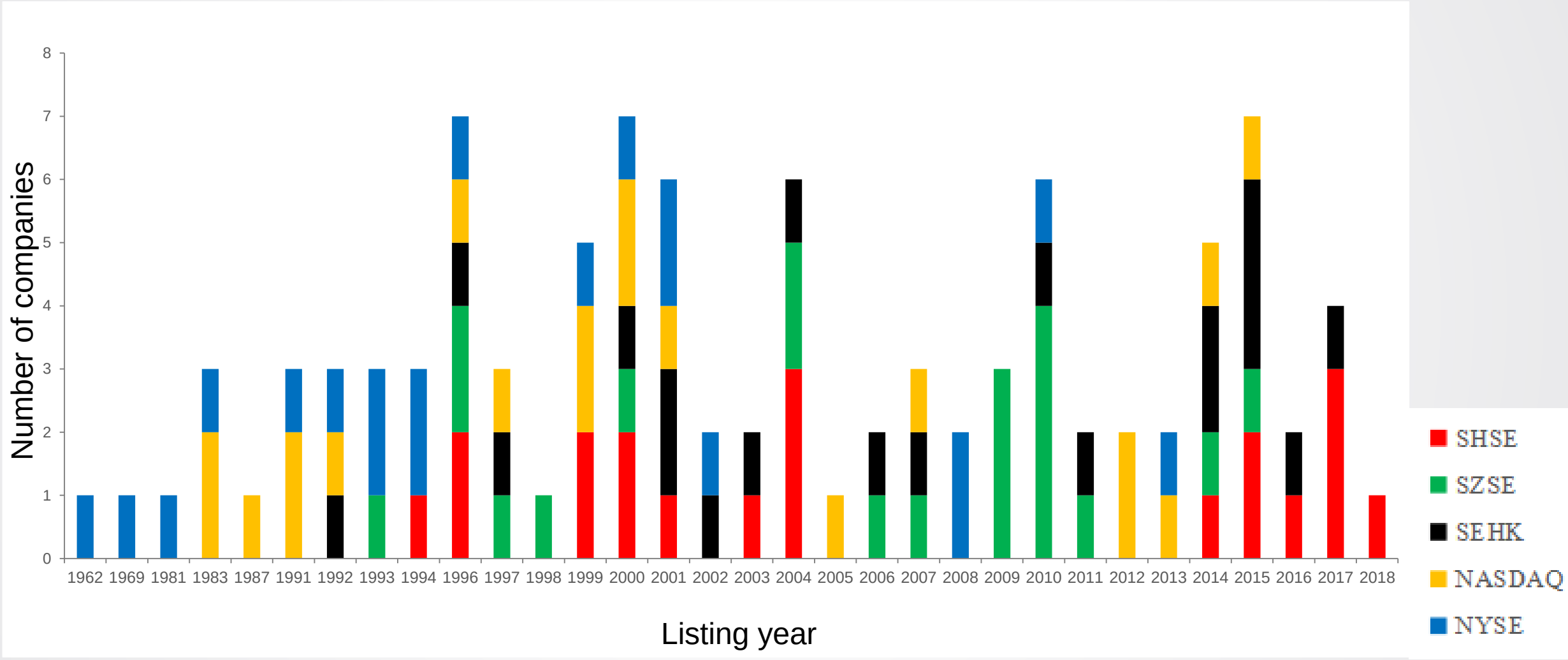


Number of patent inventors in five stock markets

Distribution for measurement variables

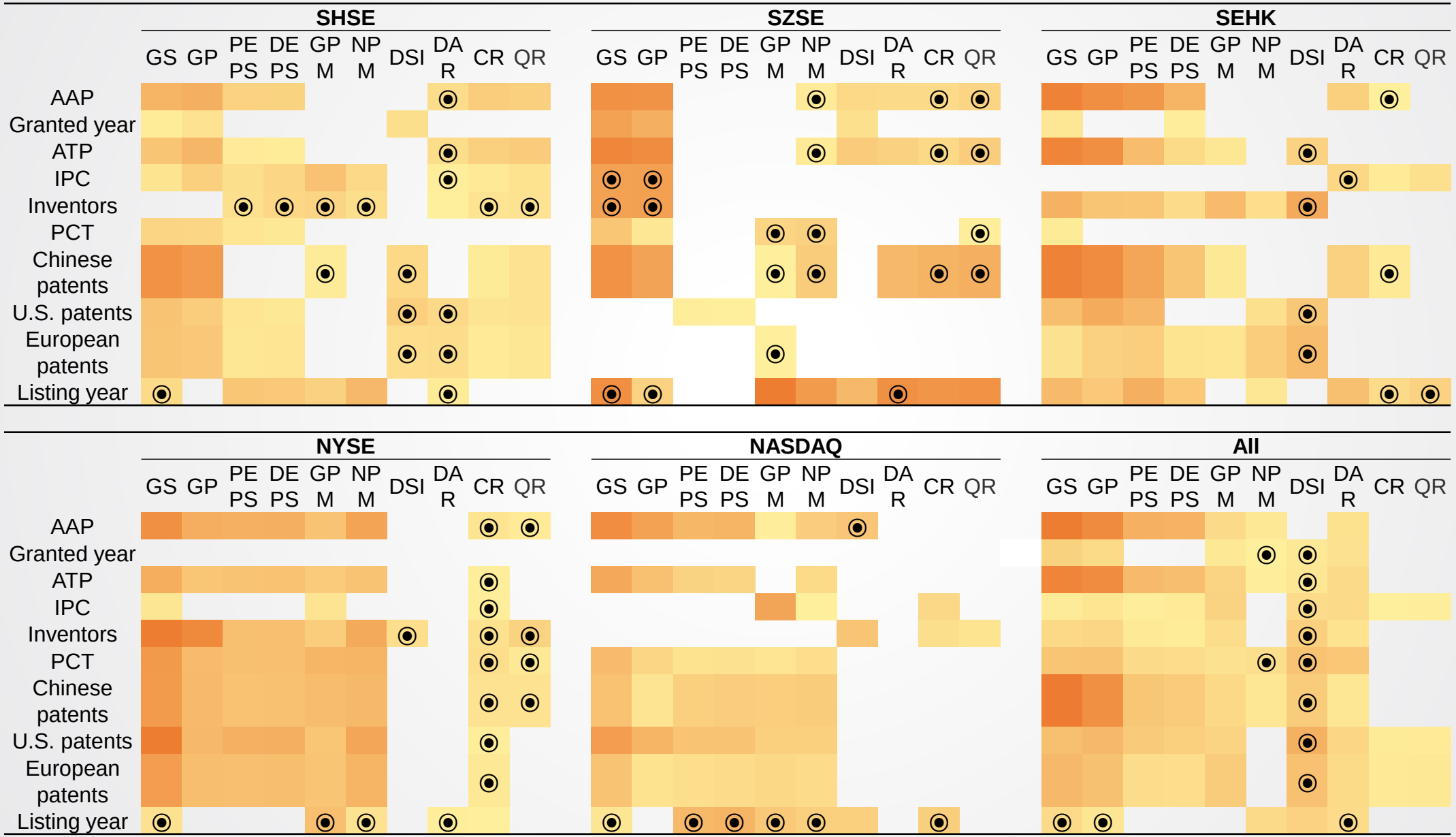


Distribution for measurement variables



Correlation between patent indicators and financial variables

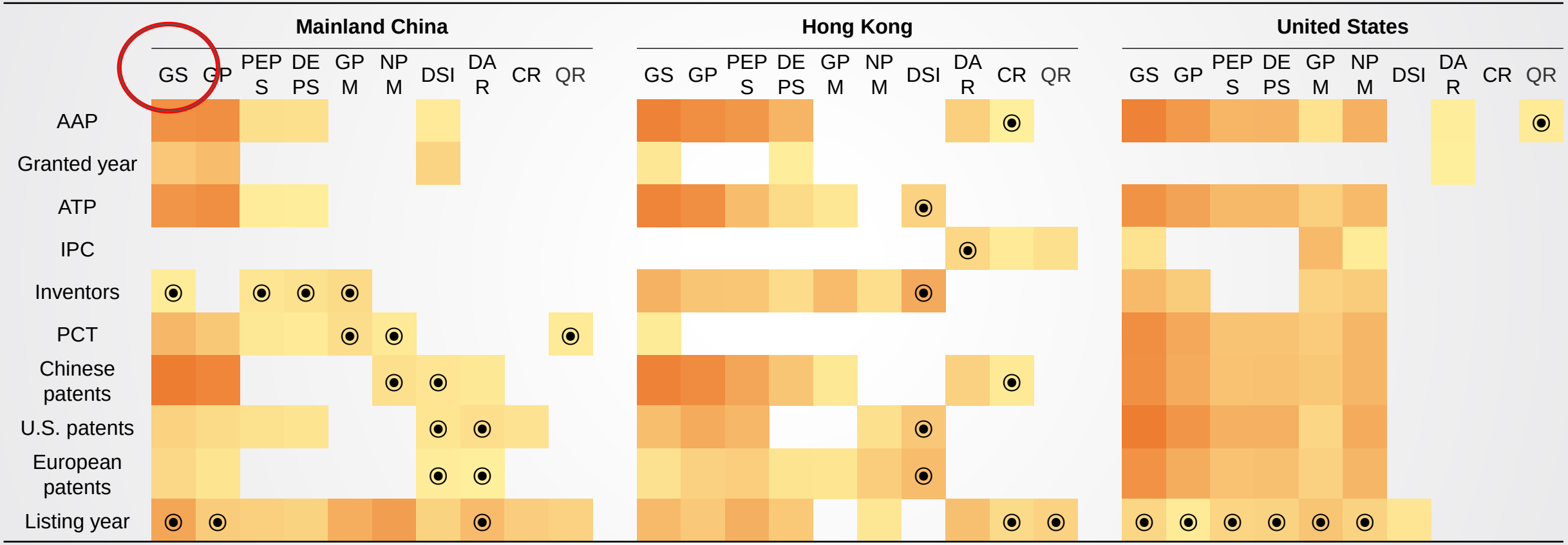
◉ Negative correlation



Correlation between patent indicators and financial variables

◉ Negative correlation

Strong correlation — Weak correlation



Patent indicators: AAP the number of annually added patents; ATP the number of annually total patents; IPC the number of IPC codes; Inventors the number of patent inventors; PCT the number of PCT patent applications; Chinese patents, U.S. patents, European patents represent the numbers of patents granted in China, in U.S., and in Europe, respectively.

Financial indicators: GS gross sales; GP gross profit; PEPS primary earnings per share; DEPS diluted earnings per share; GPM gross profit margin; NPM net profit margin; DSI days sales of inventory; DAR debt asset ratio; CR current ratio; and QR quick ratio.

Lag in the contribution of patents to gross sales

STOCK	$AAP_{LAG\text{-}YEAR}$	β(S.E)[a]	95% CI	Goodness of Fit (QICC)
Mainland China	t	75.997 (18.8946)***	38.965, 113.03	1.62894E+11
	t-1	76.922 (20.1526)***	37.423, 116.42	1.61764E+11
	t-2	84.236 (21.8832)***	41.346, 127.126	1.63029E+11
	t-3	85.201 (23.5368)***	39.07, 131.332	1.63628E+11
	t-4	93.984 (25.6884)***	43.636, 144.333	1.65052E+11
Hong Kong	t	-36.419 (15.0616)**	-65.939, -6.899	2.73627E+11
	t-1	84.663 (10.9482)***	63.205, 106.121	1.20094E+11
	t-2	81.449 (20.648)***	40.979, 121.918	1.13903E+11
	t-3	-86.622 (21.1855)***	-128.145, -45.1	3.45747E+11
	t-4	90.692 (49.7483)	-6.813, 188.196	1.33559E+11
United States	t	-161.0429 (25.3775)***	--210.781, -111.303	8.59496E+11
	t-1	-320.58 (24.3263)***	-368.259, -272.902	8.87236E+11
	t-2	780.276 (28.042)***	725.315, 835.238	7.26163E+11
	t-3	-263.389 (22.2566)***	-307.011, -219.766	8.57833E+11
	t-4	9309.547 (677.3694)	-1018.073, 1637.167	2.85994E+11

Dependent Variable: SQRT-gross sales; AAP represents the annually added patents; CI represents the confidence interval; QICC represents the corrected quasi likelihood under independence model criterion (Information criteria are in smaller-is-better form, computed using the full log quasi-likelihood function); t represents the time year. *P < 0.05; **P < 0.01; ***P < 0.001. [a]Adding AAP to the basic model (model 1) of GEE, with additional controlling the firm size and measured years;

Gross sales modeled by t-1 patent indicators in the Mainland

	Parameters	Bivariate analysis	Multivariate analysis	
			Model 1	Model 2
		β(S.E)	β(S.E)	β(S.E)
Mainland China (N=339)	AAP	**78.498 (21.4416)*****	**76.922 (20.1526)*****	**32.322 (12.4813)****
	Firm size	**0.079 (0.0247)*****	**0.073 (0.0276)****	**0.105 (0.0276)*****
	Granted year	**2092.918 (601.214)*****	1600.726 (1222.8128)	**2102.353 (607.2765)*****
	Listing year	**-1262.413 (323.2864)*****		**-1166.232 (298.0012)*****
	Chinese patents	**112.121 (27.4851)*****		**60.957 (16.1996)*****
	U.S. patents	**433.1 (67.8924)*****		156.642 (226.4328)
	PCT	**369.966 (113.3791)*****		-258.048 (213.7499)
	Brand-name drugs	**14407.023 (6711.4999)***		99.025 (5565.2204)
	Inventors	-1423.667 (1760.9666)		
	IPC	43.526 (2198.0159)		
	Blockbuster drugs	6266.898 (6008.4627)		
	Goodness of Fit (QICC)		1.61764E+11	1.412E+11

Gross sales modeled by t-2 patent indicators in HK

	Parameters	Bivariate analysis	Multivariate analysis	
			Model 1	Model 2
		β(S.E)	β(S.E)	β(S.E)
Hong Kong (N=158)	AAP	**241.658 (28.0572)*** **	**81.449 (20.648)*** **	**162.095 (51.8434)** **
	Firm size	**0.494 (0.0929)*** **	**0.309 (0.0936)*** **	-0.073 (0.0549)
	Granted year	4473.497 (3712.3944)	2928.663 (3567.5336)	4082.248 (3823.1103)
	Listing year	**2531.934 (1241.4196)***		-1273.73 (1451.9116)
	PCT	**127216.277 (18090.9738)*** **		**44869.861 (17374.3672)** **
	Chinese patents	**2436.3 (977.6897)***		**299.216 (60.6687)*** **
	Blockbuster drugs	**52585.944 (18857.7766)** **		**79231.265 (26994.765)** **
	U.S. patents	**148.06 (28.9549)*** **		
	Inventors	6792.784 (6036.6728)		
	IPC	-5991.875 (5177.4993)		
	Brand-name drugs	15066.627 (20201.0831)		
	Goodness of Fit (QICC)		1.13903E+11	1.095E+11

Gross sales modeled by t-2 patent indicators in USA

	Parameters	Bivariate analysis	Multivariate analysis	
			Model 1	Model 2
		β(S.E)	β(S.E)	β(S.E)
United States (N=200)	AAP	**450.145 (20.892)*** **	**780.276 (28.042)*** **	**860.759 (199.6263)*** **
	Granted year	**5439.549 (2251.2864)***	**7247.445 (3124.9899)***	**4430.931 (1838.5099)***
	Firm size	**0.006 (0.0022)****	**0.057 (0.0028)*** **	**0.005 (0.0021)***
	Listing year	**-2119.823 (1080.7213)***		-488.808 (1438.7768)
	U.S. patents	**116.967 (41.7632)****		**52.728 (18.2386)***
	Inventors	**25680.525 (11716.3461)***		15860.377 (12403.1904)
	Blockbuster drugs	**79353.971 (3727.4758)***		163.544 (53465.3523)
	PCT	**64.704 (22.4859)****		69.17 (57.1561)
	Chinese patents	**44.902 (17.8731)***		
	IPC	1783.366 (4094.3387)		
	Brand-name drugs	22912.458 (43233.5362)		
	Goodness of Fit (QICC)		7.26163E+11	7.052E+11

Conclusion

This study was firstly conducted to investigate the impact of patents assets on subsequent changes of financial performance of pharmaceutical firms listed in the United States and China.

- From the angle of listed company, Chinese drug industry is significantly influenced by patents, though regional differences exist.

- A significant positive relationship was found between annually added patents and sales of pharmaceutical firms.

- Firms in Hong Kong and the United States are financially affected by patents with a lag time of two years, while a one-year lag time in the Mainland China.

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