Periodica Polytechnica
Social and Management
Sciences

23(1), pp. 25-40, 2015
DOI: 10.3311/PPso.7967

RESEARCH ARTICLE

R&D, Patent Arrangements, and Financial Performances: Evidence from Taiwan

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Received 29 August 2014; accepted 11 February 2015

Abstract
In this study, we investigate the relationships among R&D, patent arrangements, and financial performances for the firms listed on the Taiwan Stock Exchange (TWSE). In particular, we apply Vector Autoregression (VAR) to examine the relationships of the listed firms classified as industries of Semiconductor, Computer and Peripheral Equipment, Optoelectronic, Communications and Internet, Electronic Parts & Components, Electronic Products Distribution, and Other Electronic, by the TWSE. In sum, we find the different lead-lag relationships among R&D, patent arrangements, and financial performances in different industries, indicating important insight into patent arrangements.

Keywords
R&D, Patents, Financial Performances, TWSE

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1 Introduction

In recent years, corporations attach importance to creativity more because human being is into the „creative economy" era from labour-intensive industrial age. Howkins (2001) points out that the creative economy should protect products developed by firms through the intellectual property rights. Furthermore, Edvinsson (1997) indicates that successful firms require knowledge and organizing ability to have industrial competitiveness or produce intellectual property rights. Thus, the input of research and development (R&D) and output of intellectual property is a key factor to enhance the value of firms and create competitive advantages.

In addition to new products and new technology, intellectual property rights are also significant to evaluate corporations' outputs. In particular, patents may also demonstrate the ability on R&D and development of innovation. In 2012, Taiwanese corporations have 23,349, 20,270, 2,983, 2,082 new patents in China, the U.S., Japan, and Europe, respectively. However, the number of new patents Taiwanese corporations is decreasing in the U.S., Japan, and Europe. Therefore, it shows that Taiwanese corporations are facing challenges on innovation and R&D capabilities under the competition of foreign corporations. Thus, Taiwanese firms have to strengthen the ability to research on new patens, and pay more attention on patent arrangement in overseas markets to create competitive advantages because patent is a way to protect intellectual property rights in law (Bessler and Bittelmeyer, 2008). Furthermore, Griliches (1981) and Bloom and Reenen (2002) suggest that it always increases opportunities to profit for corporations to develop new innovative products or manufacture improvement. Accordingly, it may positively impact a corporation's long-term financial performance, and immediately reflect in its market value.

On the other hand, R&D expenditure should be regarded as investment. However, if corporations fail to obtain patent protection of the achievements from R&D, it may be ineffective for corporations because their competitors may follow such achievements without any restriction. Thus, the relationship between R&D and financial performance is not necessarily positive. Furthermore, we should respectively investigate the relationships among R&D expenditure, patents, and financial performance. In addition, different market competitiveness (e.g., monopoly or oligopoly) also influences corporations' decisions to arrange their patents in international markets. To the best of my knowledge, only limiting studies focus on such relationships.

The remainder of the paper is organized as follows: section II presents the data from Taiwan Stock Exchange (TWSE) and introduces the methodology, section III presents the empirical findings regarding order imbalances, and section IV summarizes the results and concludes.

2 Literature review

A patent is only valid in a particular country when the government gives the corporation the authority in law. In other words, the patent system is *jus soli*. Lanjouw et al. (1998), document that a patent has a greater influence and importance if it is applied in several major countries. In particular, Grupp and Schmoch (1999) indicate that patents are more considerable if they are quoted from the U.S., Europe, and Japan. Therefore, in order to effectively protect important R&D achievements, corporations should apply for patents globally, at least apply for patents in their key markets.

Some studies use number of patents as the measure of R&D output. However, Jaffe and Trajtenberg (1999) and Kelley and Rice (2002) point out that the number of patents cannot cover the entire R&D, both in scope and in depth. Furthermore, number of patents is likely to lead to biases, which ignore importance and potential value among patents. However, no empirical studies suggest a perfect patent quality indicator.

On the other hand, although some studies indicate that it may lead to biases to measure R&D by number of patents (*e.g.*, Pakes and Griliches, 1980), and Hall *et al.* (2001) further point out that not all R&D achievements are able to be patented, and number of patents does not necessarily stand for economic benefits, Hall and Bagchi-Sen (2002) suggest that the number of patents does reflect a corporation's degree of R&D ability and innovation, enabling a corporation to step back and grasp the pulse of technology in markets and further prevent her competitors from replication. Hitt et al. (1991) point out that patents represent the commercialization of research results in high-tech industry.

More importantly, R&D expenditures are always significant in a corporation's financial statement because R&D is important to maintain her competitiveness. Hsu et al. (2013) propose that the relationship between R&D expenditures and profits is not positive and linear. Furthermore, Huang et al. (2008) point out that R&D expenditures relate to the company's high growth and internal and external information asymmetry. Thus, Chiu et al. (2012) document a firm tends to use internal capital in R&D because of such information asymmetry.

However, Nelson (1982) points out that the accumulated research experience positively influences the follow-up R&D activities, and further improves the future performance of a firm. In addition, McKelvey (1982) finds that the transformation of technical activities input into output is crucial to survive for a firm. That is, in a dynamic environment, technological innovation plays an important role for a firm to obtain and maintain her competitive advantage, as well as improve her performance. In addition, Toivanen et al. (2002) show that R&D and innovation positive impact the market value for UK's firms. Also, Bharadwaj et al. (1999) document that R&D can improve productivity, and create rapid and effective innovation for high-tech firms.

Furthermore, Madanmohan et al. (2004) show that the improvement of human resources or technology positively influences a firm's value, but R&D lags practical applications. Empirical studies validate such viewpoints. For example, Hirschey and Weygandt (1985) indicate that R&D expenditures lag a firm's payback for 5 to 10 years.

There are some studies investigating the relationship between R&D expenditures and firm value (e.g., Lantz and Sahut, 2005). However, most studies focus on R&D expenditures and patents, and firm value is divided as the sum of tangible and intangible assets. In particular, literature uses Tobin's Q (Tobin, 1978), namely the ratio of market capitalization value to net book value, to explain the relationship between R&D and market value. However, Wernerfelt and Montgomery (1988) document that the imbalance of Tobin's Q may be due to off-balance sheet items (e.g., retirement provisions) or strategies (e.g., monopoly and diversification). Therefore, some papers indicate it in doubt to use Tobin's Q as the measure of intangible (e.g., Griliches, 1981; Cockburn and Griliches, 1988; Megna and Klock, 1993; Chung and Pruitt, 1996).

However, many studies still use Tobin's Q as the proxy of intangible expenses because Tobin's Q is highly related to intangible expenses (e.g., Hirschey and Weygandt, 1985; Skinner, 1993; Agrawal and Knoeber, 1996). These studies indicate that the relationship between R&D expenditures and market value of a firm is significantly positive. In addition, Pakes (1985) find that R&D expenditures and number of patents positively influence firms' value. Using the data of the U.S. listed firms, Sougiannis (1994) shows that the net income of a firm will rise by two dollars when R&D expenses increase for one dollar, and the lag time is over more than seven years, representing an average annual rate of 26% and one dollar spent in R&D increases a firm's market value by nearly three dollars. On the other hand, Sundaram et al. (1996) have the opposite conclusions. They find that the relationship between R&D expenditures and stock prices is not significantly positive because the reaction of stock prices depends on the level of competition in industry, i.e., increasing R&D expenditures pushes stock prices in less competitive industries, but decreasing R&D expenditures makes stock prices to fall in competitive industries.

Schmookler (1966) first uses statistics of patent as a proxy for innovation activities. Furthermore, Ernst (1995) further analyse patents in various levels, including country, industry, and technology. Ashton and Sen (1989) point out that patents provide unique information to manage enterprise resource or product, and patents can systematically evaluate the relative competitive position in a regional market. Griliches (1998) empirically explore the relationship between R&D expenditures and patent activity, and he finds a positive relationship between them. In addition, Narin and Noma (1987) show that the relationship between technical competitiveness is positive, but the relationship between patents and financial performance is insignificant. Furthermore, Griliches et al. (1991) discuss how patents influence market capitalization through the sample including 340 firms, and conclude that only patents contribute only a small part in market value changes.

Edvinsson and Malone (1997) indicate that intellectual property arising from R&D should be properly understood and managed to reflect in financial performance. In particular, patents are intellectual property rights and regarded as an output of R&D. Furthermore, Lilien and Yoon (1989) show that firms will be able to effectively innovate and improve their extant products if they have more patents. Crepon et al. (1998) find that the relationships among R&D expenditures, firm size, market share and needs of technology are significant.

In addition, Hall and Bagchi-Sen (2002) propose that patents from R&D have a positive impact on productivity, and thus relate to financial performance, and R&D activities and the number of patents can firmly ensure a firm's performance (Beneito, 2006). Therefore, innovation promotes long-term competitive advantage of a firm, and patents will eventually react to financial performance. While there is extensive literature that uses patents to measure technology level on national or regional, or use patents to measure individual firm's technology, Neuhäusler et al. (2011) point out that studies on patents and financial performance are still rare.

Using the patents and related citations during 1963 and 1999, Hall et al. (2005) find that market value, patents, as well as patent citations show a positive relationship. Chen and Chang (2010) also document that the relationships among patents, patent citations, and market value are positive in pharmaceutical industry. In addition, Levitas and Chi (2010) uses the concept of real options to analyse the effects of patents and capital investment of technology on opportunities to create value in the future.

Moreover, Ben-Zion (1978) documents different views on R&D expenses, which are treated as current expenses in accounting, because most of the R&D expenditures have future benefits, and thus have deferred impact on financial performance. Thus, R&D expenditures should be recognized capital expenditures, at least part them, to reflect the deferred benefits. Furthermore, Hirschey and Weygandt (1985) indicate that R&D expenditures should be capitalized to be amortized over years because R&D expenditures are positively related to firms' value, and R&D expenditures continue the impact for 5 to 10 years.

3 Data and methodology

This study will investigate firms listed on the Taiwan Stock Exchange (TWSE). The studying period covers from 2001 through 2012, a total of twelve years. The data on financial performance of listed firms are obtained from Taiwan Economic Journal (TEJ). The patent information and patent approved data will be taken from the patent search systems of the Taiwan Intellectual Property Office (TIPO), State Intellectual Property Office of the P.R.C. (SIPO), and the United States Patent and Trademark Office (USPTO).

In order to capture the delay of the effect of R&D expenditures, number of patents, and financial performance, we employ the Vector Auto Regression (VAR) models. VAR models take into account the time lapse among R&D expenditures, number of patents, and financial performance by including their lag terms and relaxing the assumption on the choice of lag terms of the variables. Also, the models relax any assumptions on the causal directions among R&D expenditures, number of patents, and financial performance. Instead of assuming any variable functions as cause or effect, VAR models provide *ex post* causal information by tracing the interaction among the variables. Moreover, we control for the industry-specific effect in VAR according to the industry category by TWSE. Specifically, for each industry category, we have nine VAR models:

$$RD_t = a_1 + \sum_{l=1}^{m} b_{1,l} RD_{t-l} + \sum_{l=1}^{m} c_{1,l} PT_{t-l} + \sum_{l=1}^{m} f_{1,l} FP_{t-l} + g_1 B_t + \varepsilon_{1,t}$$

$$PT_t = a_2 + \sum_{l=1}^{m} b_{2,l} RD_{t-l} + \sum_{l=1}^{m} c_{2,l} PT_{t-l} + \sum_{l=1}^{m} f_{2,l} FP_{t-l} + g_2 B_t + \varepsilon_{2,t}$$

$$FP_t = a_5 + \sum_{l=1}^{m} b_{5,l} RD_{t-l} + \sum_{l=1}^{m} c_{5,l} PT_{t-l} + \sum_{l=1}^{m} f_{5,l} FP_{t-l} + g_5 B_t + \varepsilon_{3,t} \quad (1)$$

where RD_t is the ratio of R&D expenditures to sales in year t, PT_t is number of patents obtained in Taiwan, China, and the U.S. (i.e., TW, CN, and US, respectively), in year t, FP_t is financial performance (i.e., ROA, ROE, and EPS, respectively) in year t, B_t is the business cycle index, and m is the maximum number of lag terms of each variable, and ε is supposed to be a white noise. The business cycle index is included as control variables because many studies emphasize the impact of business cycles on the firms' operations and financial performance. For example, Horrigan (1965) proposes that financial ratios are related to business cycles, and Richardson et al. (1998) document that many financial ratios are significantly different during the period of economic recession.

VAR relaxes the restraints that are usually exerted on the relationship among R&D expenditures, number of patents, and financial performance. VAR makes no assumptions on which lag terms or how many lag terms needed to include in the model. In practice, we use Akaike Information Criteria (AIC) to judge how many lag terms should be most reliable and maximum amount of information out of the data. In particular, we will obtain nine models for Taiwan, China, and U.S., enabling us to better understand how different patent arrangements in these countries affect financial performance.

4 Empirical analysis

In this study, we delete the firms which spend no R&D expenditure or/and have no patents in Taiwan, China, or China during the sample period, and the sample covers 73 firms after the deletion.

In Table 1, we present the summary statistics for patents and financial performances, respectively. In general, most firms have more patents in Taiwan, and only the firms in the semiconductor industry have more patents in the U.S. than Taiwan (i.e., mean of US=658.80 and mean of TW=624.10). Furthermore, as panel A of Table 1 presents, on average the firms in the semiconductor, optoelectronic and other electronics industries have more patents in Taiwan, China, and the U.S. on the other hand, the firms in semiconductor, communications and internet, and other electronics industries spend more on R&D, but the firms in computer and peripheral equipment, communications and internet, and other electronics have relatively better financial performances. Thus, the results of Table 1 indicate the differences in number of patents, finance performances, and R&D expenditure for different industries, implying that we should discuss the relationship among R&D expenditure, patents, and financial performances by industry types.

After examining the summary statistics, we use the unit root test to determine whether the variables are stationary. As the results of panel A in Table 2 shows, all the statistics are insignificant in the ADF tests, indicating the variables are non-stationary. Thus, we take first-order difference for the variables, and do the ADF tests again for the differenced variables. Panel B of Table 2 presents the results of the tests. It shows that the statistics are highly significant at the 1% level, indicating that the variables are stationary after the first-order difference.

Since the unit root tests show that the variables are non-stationary and stationary after the first-order difference, it is *I (1)*. We further take Johansen (1988) cointegration tests to explore whether the long-term equilibrium exists among patent, R&D expense, and finance performance.

In order to determine whether there are cointegration relationships among number of patents, R&D expense, and financial performance, we perform the Johansen (1988) cointegration test, and the results are reported in Table 3. Both the maximum eigenvalue and the trace statistics indicate that there is no cointegration vector because we do reject the null hypothesis for $r \leqq 0$ in λ_{trace}, and we neither do not the null hypothesis for $r = 0$ in λ_{max}, at the 1% significance level.

Since the variables are stationary after first order difference, and the there is no co-integration relationships among differenced variables, we apply VAR to analyse the relationships among R&D expenditure, number of patents, and financial performance for the seven electronic industry types.

In general, the financial performance of firms in electronic industries are positively related to the business cycle index as evidenced by the estimated coefficient of B_t being positively significant (e.g., model I for semiconductor, computer and peripheral equipment, optoelectronic, electronic parts and components, and other electronic). However, financial performances of firms in some industries are less influenced by the business cycle index (e.g., models I~IX for communications and internet and electronic products distribution).

Furthermore, the empirical results demonstrate that R&D expenditures have mixed effects on financial performances. For other electronic industry, the effect is positive as evidenced by the estimated coefficient of RD_{t-1} being significant at the 5% level in models I, II, III, VI, VII, VIII, and IX, consistent with Toivanen et al. (2002) and Bharadwaj et al. (1999). On the other hand, the effects are insignificant for most industry types, consistent with Sundaram et al. (1996). Interestingly, such effects are even negative for semiconductor and optoelectronic industries (i.e., models II, IV, V, VII and VIII for semiconductor and models I, II, and IX for optoelectronic), which are the two potential electronic industries Taiwanese government focused on[1] these years, indicating the collapse of many firms in the two industries. However, the empirical results indicate that number of Taiwanese patents lead to better financial performances (i.e., models I, II, and III for semiconductor and models I and III for optoelectronic). Thus, it shows the importance of developing the own core technology in the form of patents. In particular, during the past two decades, all Taiwanese Dynamic Random Access Memory (DRAM) firms bought ready-made technology and core patents to produce DRAM chips. Without their own proprietary technology, Taiwanese DRAM manufacturers have to spend a lot of money to look for new technology licensing once the economy worsening and their technology source having problems. For example, ProMOS, once a highly profitable DRAM manufacturer, has to rely on technology licensing from Germany's Infineon, South Korea's Hynix, and Japan's Elpida, because ProMOS fail to develop her own patents in the DRAM industry.

On the other hand, there are similar effects of R&D expenditures on financial performances in models IV, V, VII and VIII for semiconductor, model IX for optoelectronic, and models IV, V, VII and VIII for other electronic. However, numbers of patents in China and the U.S. (i.e., CN_{t-1} and US_{t-1}) have insignificant impact on financial performances. Since the summary statistics show that most firms have fewer patents in China and the U.S., it is not surprising that CN_{t-1} and US_{t-1} have minute econometrical influence. However, it is worth noting that other electronics industry, which has most patents in Taiwan, China, and the U.S. across all industries, is the most profitable, and

1 In 2002, the Taiwanese government proposed the 'Two Trillion and Twin Star Development Program' for semiconductor and optoelectronic industries, giving the two industries many tax incentives.

Table 1 Basic Statistics

Panel A. Number of patents							
	Semiconductor	**Computer and Peripheral Equipment**	**Optoelectronic**	**Communications and Internet**	**Electronic Parts and Components**	**Electronic Products Distribution**	**Other Electronic**
TW							
Min	0.00	0.00	8.00	2.00	0.00	2.00	0.00
Median	274.00	149.00	67.00	103.00	14.00	14.00	132.00
Mean	624.10	446.10	551.70	166.20	249.00	13.40	1706.00
Max	3296.00	3156.00	3862.00	811.00	2294.00	34.00	14600.00
S.D.	857.33	692.03	1254.04	250.67	634.22	12.88	4542.13
CN							
Min	0.00	0.00	0.00	1.00	0.00	0.00	0.00
Median	86.00	112.00	14.00	39.00	5.00	1.00	49.50
Mean	360.80	270.10	506.80	41.00	155.10	120.60	1129.00
Max	1910.00	2343.00	3867.00	101.00	1396.00	601.00	9926.00
S.D.	557.46	469.82	1267.56	31.39	395.32	268.55	3100.97
US							
Min	0.00	0.00	5.00	1.00	0.00	0.00	0.00
Median	188.00	28.00	19.00	31.00	1.00	0.00	15.00
Mean	658.80	126.20	333.00	34.67	143.60	7.80	1399.00
Max	5372.00	729.00	2546.00	113.00	1273.00	38.00	12440.00
S.D.	1215.76	208.20	833.31	35.60	373.17	16.89	3898.86
Panel B. Financial performances and R&D							
ROE (%)							
Min	-286.60	-128.07	-52.20	-53.84	-177.57	-2118.26	-57.86
Median	3.77	9.10	3.00	7.50	5.79	8.86	12.07
Mean	-2.61	5.28	2.78	3.22	1.94	-36.89	9.37
Max	37.22	94.70	33.10	23.91	53.82	44.57	31.05
S.D.	27.65	21.49	14.26	14.69	20.89	276.20	13.96
ROA (%)							
Min	-58.43	-33.30	-29.86	-20.16	-32.27	-438.86	-16.73
Median	2.96	4.74	2.33	4.29	3.77	4.61	6.84
Mean	0.72	4.13	2.30	3.18	2.79	-4.82	5.76
Max	27.96	61.62	18.68	15.09	17.51	16.81	19.72
S.D.	11.73	9.09	7.84	7.22	6.70	5.75	6.43
EPS (TWD/Share)							
Min	-9.38	-10.78	-6.94	-4.85	-5.80	-52.32	-5.03
Median	0.48	1.55	0.52	1.20	0.83	1.27	1.84
Mean	0.27	1.81	0.72	1.32	1.02	0.48	2.61
Max	6.73	29.79	7.22	6.04	7.18	9.55	12.35
S.D.	2.58	3.38	2.71	2.36	2.16	7.51	3.26
R&D Expenditure/Sales (%)							
Min	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Median	4.23	1.99	2.69	3.83	1.25	0.45	1.38
Mean	9.05	3.21	2.95	4.04	1.78	0.64	2.62
Max	184.75	46.40	13.68	17.32	6.48	8.08	10.41
S.D.	15.64	4.27	1.82	2.44	1.76	1.12	2.73

electronic products distribution industry, which has least patents in Taiwan and the U.S., is the only industry that ROA and ROE are negative on average.

In sum, our empirical results indicate that R&D expenditures may differently influence financial performances, i.e., positively (Toivanen et al., 2002; Bharadwaj et al., 1999) or negatively (Sundaram et al., 1996), because of diversified industry characteristics. More importantly, we document that patent arrangements are significant to firms' financial performances, by controlling the possible effects from R&D expenditures.

Table 2 Unit root tests

Panel A.

		RD	*TW*	*CN*	*US*	*ROE*	*ROA*	*EPS*
Semiconductor	Intercept	-1.518	-1.290	-1.659	-1.449	-2.532	-2.423	-2.254
	Trend and intercept	-2.396	-2.561	-2.143	-2.249	-2.419	-2.573	-2.370
	None	0.160	-1.474	-1.311	-1.897	-1.209	-1.224	-1.098
Computer and Peripheral Equipment	Intercept	-1.014	-1.406	-1.493	-1.775	-1.993	-1.882	-1.808
	Trend and intercept	-2.091	-2.658	-1.882	-2.241	-2.158	-2.000	-2.028
	None	0.623	-0.859	-0.727	-1.124	-1.175	-1.459	-1.030
Optoelectronic	Intercept	-1.834	-1.598	-1.927	-2.411	-1.523	-1.471	-1.458
	Trend and intercept	-2.368	-1.574	-2.217	-3.099	-1.841	-2.064	-1.589
	None	-0.546	-1.196	-1.102	-1.535	-0.929	-1.198	-0.825
Communications and Internet	Intercept	-1.248	-1.818	-2.236	-2.194	-1.358	-1.323	-1.704
	Trend and intercept	-1.923	-2.326	-2.026	-3.024	-2.886	-2.942	-2.777
	None	-0.446	-1.344	-1.149	-1.819	-0.600	-1.026	-0.679
Electronic Parts and Components	Intercept	-2.314	-1.756	-1.996	-2.236	-2.053	-2.198	-1.854
	Trend and intercept	-2.080	-2.660	-2.143	-2.309	-2.465	-2.577	-2.667
	None	-0.443	-1.006	-0.962	-2.000	-0.811	-1.108	-0.757
Electronic Products Distribution	Intercept	-0.672	-2.291	0.095	-2.595	-2.807	-2.213	-2.420
	Trend and intercept	-2.032	-2.097	-2.822	17.450	-2.765	-2.243	-2.463
	None	-1.130	-1.564	1.751	-1.160	-1.591	-1.046	-1.183
Other Electronic	Intercept	-1.207	-1.692	-1.752	-1.742	-2.115	-2.328	-2.700
	Trend and intercept	-2.484	-2.195	-2.561	-1.310	-2.654	-2.686	-2.278
	None	0.056	-1.016	-0.813	-0.908	-1.270	-1.599	-0.837

Panel B.

		RD	*TW*	*CN*	*US*	*ROE*	*ROA*	*EPS*
Semiconductor	Intercept	-22.823***	-22.530***	-22.947***	-22.570***	-23.202***	-23.388***	-23.212***
	Trend and intercept	-23.047***	-22.367***	-22.953***	-23.327***	-23.530***	-23.449***	-23.346***
	None	-22.581***	-22.804***	-22.777***	-22.458***	-23.175***	-23.290***	-23.150***
Computer and Peripheral Equipment	Intercept	-22.538***	-22.817***	-22.613***	-22.548***	-22.553***	-22.495***	-22.459***
	Trend and intercept	-22.960***	-22.485***	-23.084***	-22.925***	-22.625***	-22.759***	-22.625***
	None	-22.204***	-22.681***	-22.510***	-22.356***	-22.584***	-22.465***	-22.564***
Optoelectronic	Intercept	-22.556***	-22.100***	-22.122	-22.940***	-22.229***	-22.319***	-22.230***
	Trend and intercept	-22.739***	-22.926***	-22.093***	-23.448***	-22.968***	-22.787***	-23.081***
	None	-22.440***	-22.210***	-22.276***	-23.077***	-22.295***	-22.348***	-22.357***
Communications and Internet	Intercept	-22.486***	-23.019***	-22.856***	-23.925***	-22.915***	-23.612***	-23.976***
	Trend and intercept	-22.794***	-22.930***	-23.242***	-24.589***	-23.294***	-23.798***	-24.012***
	None	-22.554***	-23.119***	-22.878***	-23.546***	-22.772***	-23.359***	-23.644***
Electronic Parts and Components	Intercept	-32.433***	-32.198***	-32.679***	-33.600***	-32.917***	-32.845***	-33.205***
	Trend and intercept	-33.448***	-32.045***	-32.860***	-33.795***	-33.109***	-32.754***	-33.200***
	None	-32.313***	-32.276***	-32.762***	-33.503***	-32.859***	-32.867***	-33.024***
Electronic Products Distribution	Intercept	-32.759***	-32.827***	-32.850***	-36.878***	-33.984***	-33.768***	-33.769***
	Trend and intercept	-32.842***	-32.852***	-32.530***	-35.578***	-33.672***	-33.646***	-33.647***
	None	-32.461***	-33.059***	-31.220***	-35.903***	-34.292***	-34.047***	-34.058***
Other Electronic	Intercept	-32.521***	-32.075***	-32.250***	-31.886***	-33.501***	-34.280***	-33.594***
	Trend and intercept	-32.913***	-32.357***	-32.354***	-31.891***	-33.406***	-34.249***	-33.585***
	None	-32.307***	-32.007***	-32.056***	-31.980***	-33.424***	-33.997***	-33.625***

Notes:

1. The models for ADF unit root test are:

Intercept: $\Delta y_t = \alpha_0 + \gamma y_{t-1} + \sum_{i=2}^{p} \beta_i \Delta y_{t-i+1} + \varepsilon_t$.

Trend and intercept : $\Delta y_t = \alpha_0 + \gamma y_{t-1} + \alpha_2 t + \sum_{i=2}^{p} \beta_i \Delta y_{t-i+1} + \varepsilon_t$.

None: $\Delta y_t = \gamma y_{t-1} + \sum_{i=2}^{p} \beta_i \Delta y_{t-i+1} + \varepsilon_t$,

where y_t is the time series, t is the trend , and ε_t is the residual.

The null hypothesis for ADF test is $H_0 : \gamma = 0$.

2. The number in parentheses denotes the lag length, determined via the Akaike's Information Criterion (AIC).

3. The symbol *** denotes for significance at the 1% level.

Table 3 Johansen test for cointegration

Panel A. Trace

		ROE			***ROA***			***EPS***		
		r≦2	r≦1	r≦0	r≦2	r≦1	r≦0	r≦2	r≦1	r≦0
Semiconductor	TW	4.333	9.550	14.312	4.415	13.290	14.775	3.800	9.280	12.352
	CN	4.416	10.869	13.258	5.146	9.321	12.019	4.661	8.902	13.194
	US	3.479	9.995	12.465	4.049	13.190	14.784	3.902	10.071	13.195
Computer and Peripheral Equipment	TW	4.011	12.266	13.017	4.189	8.279	12.252	4.517	9.630	12.121
	CN	3.996	13.598	14.196	4.044	12.810	14.025	3.589	9.800	13.014
	US	3.764	13.500	14.735	3.689	12.970	14.314	3.579	9.788	13.015
Optoelectronic	TW	4.598	12.522	14.725	4.488	8.012	12.823	5.472	9.570	15.863
	CN	5.061	11.249	13.324	4.984	10.492	14.145	3.710	9.110	13.225
	US	4.077	13.458	15.414	4.281	12.030	14.898	3.665	8.600	11.989
Communications and Internet	TW	2.068	9.390	12.178	3.549	6.080	11.425	3.628	9.310	13.896
	CN	2.454	8.552	11.954	7.555	11.980	15.663	3.713	8.630	10.657
	US	2.840	2.410	11.835	3.107	11.370	13.565	2.224	9.080	12.125
Electronic Parts and Components	TW	4.940	12.310	14.225	5.105	12.960	14.146	5.200	8.620	13.975
	CN	4.560	6.220	12.415	4.396	5.860	12.118	4.127	6.490	12.246
	US	3.253	3.230	12.412	3.327	3.300	13.398	3.377	4.920	13.532
Electronic Products Distribution	TW	3.237	11.540	12.778	3.167	8.888	14.178	3.574	7.680	12.982
	CN	4.480	14.020	16.395	8.491	9.670	13.936	9.554	8.180	12.685
	US	6.130	8.780	15.947	9.373	6.960	14.393	9.679	6.960	11.968
Other Electronic	TW	5.508	9.163	13.419	3.923	4.225	13.329	4.226	9.930	14.134
	CN	3.043	8.020	12.493	2.309	10.460	13.318	2.283	10.080	14.843
	US	5.296	13.680	14.985	5.601	9.023	14.442	4.828	9.380	11.822

Panel B. Eigen

		ROE			***ROA***			***EPS***		
		r=2	r=1	r=0	r=2	r=1	r=0	r=2	r=1	r=0
Semiconductor	TW	4.333	5.121	11.333	4.415	8.54	10.815	3.800	6.596	10.666
	CN	4.416	7.673	10.854	5.146	5.348	10.344	4.661	5.112	11.312
	US	3.479	7.428	10.865	4.049	8.398	10.149	3.902	6.600	11.002
Computer and Peripheral Equipment	TW	4.011	7.680	10.099	4.189	7.800	9.780	4.517	6.456	10.176
	CN	3.996	8.873	10.125	4.044	7.510	9.741	3.589	7.278	11.098
	US	3.764	7.711	10.914	3.689	6.410	10.090	3.579	6.893	10.739
Optoelectronic	TW	4.598	9.136	10.055	4.488	8.850	10.080	5.472	7.018	11.128
	CN	5.061	4.551	11.263	4.984	5.347	12.175	3.710	6.203	11.303
	US	4.077	8.685	11.666	4.281	7.749	11.491	3.665	5.249	10.059
Communications and Internet	TW	2.068	7.320	10.695	3.549	8.530	9.690	3.628	5.680	11.508
	CN	2.454	6.320	13.654	5.553	6.430	8.830	3.713	7.910	8.430
	US	2.840	9.571	12.871	3.107	8.260	11.370	2.224	6.860	10.240
Electronic Parts and Components	TW	4.940	6.682	11.082	5.105	8.388	11.858	5.200	7.470	11.800
	CN	4.560	6.835	10.053	4.396	8.939	10.135	4.127	8.711	12.471
	US	3.253	8.979	10.539	3.327	6.774	11.524	3.377	7.425	11.172
Electronic Products Distribution	TW	3.237	8.300	9.502	3.167	8.240	10.060	3.574	7.100	9.170
	CN	4.480	7.540	13.603	5.491	8.180	9.940	5.554	8.630	10.353
	US	6.130	7.640	12.600	9.373	7.590	11.639	5.679	7.280	10.987
Other Electronic	TW	5.508	9.566	10.786	3.923	9.044	11.824	4.226	11.307	11.820
	CN	3.043	6.800	10.403	2.309	6.220	11.090	2.283	6.100	11.108
	US	5.296	8.250	10.350	5.601	8.815	11.515	4.828	7.610	10.721

Notes:

1. We perform the Johansen (1988) cointegration test: $\Delta y_t = \mu_t + \Pi y_{t-1} + D_1 \Delta y_{t-1} + \cdots + D_{p-1}\Delta y_{t-p+1} + \varepsilon_t$,

where $D_j = -\sum_{s=j+1}^{p} \Phi_s, j = 1,2,\cdots p-1$.

$\Pi = -\Phi(1) = -(I - \Phi_1 - \Phi_2 - \cdots - \Phi_p)$

where Πy_{t-1} is the error correction term. Rank(Π) is to determine the number of cointegration vector in y_t.
(1) There is no cointegration vector in y_t. if rank(Π)=0.
(2) y_t is stationary if rank(Π)=k.
(3) There are r cointegration vectors in y_t if rank(Π)=r and $0 < r < k$.
(4) Trace test:

$H_0: rank(\Pi) \le r$

$H_1: rank(\Pi) > r$

Trace static: $\lambda_{trace}(r) = -T\sum_{j=r+1}^{k} \ln(1-\hat{\lambda}_j)$.

(5) Maximum eigenvalue test:

$H_0: rank(\Pi) = r$

$H_1: rank(\Pi) = r + 1$

Maximum eigenvalue statistic: $\lambda_{\max}(r, r+1) = -T\ln(1-\hat{\lambda}_{r+1})$.

λ_i is the estimate of eigenvalue, r is the cointegration vector, and T is the number of observations.
2. The symbol ** denotes for significance at the 5% level.
3. λ_{trace} and λ_{max} are the statistics for trace test and maximum eigenvalue test, respectively.
4. Critical values are calculated according to MacKinnon-Haug-Michelis (1999).

Table 4 VAR

Panel A. Number of patents in Taiwan (TW)

FP		**ROE, model I**			**ROA, model II**			**EPS, model III**		
		ΔRD_t	ΔTW_t	ΔFP_t	ΔRD_t	ΔTW_t	ΔFP_t	ΔRD_t	ΔTW_t	ΔFP_t
Semiconductor	ΔRD_{t-1}	0.007875	-0.04099	-1.13863	0.03713	-0.1559	-0.54515	0.01602	-0.1722	-0.04199
		(0.020)	(0.002)	(-1.466)	(0.118)	(-0.031)	(-1.872)*	(0.044)	(-0.034)	(-1.408)
	ΔTW_{t-1}	0.003196	0.02942	0.00988	0.004266	0.04838	0.004814	0.002266	0.04024	0.002183
		(0.169)	(0.097)	(2.451)**	(0.195)	(0.145)	(2.269)**	(0.152)	(0.098)	(2.219)**
	ΔFP_{t-1}	-0.000709	0.1369	-0.4161	-0.00709	0.4376	-0.4786	-0.02542	1.979	-0.4456
		(-0.046)	(1.512)	(-2.119)**	(-0.133)	(1.478)	(-2.361)**	(-0.095)	(1.617)*	(-2.175)**
	c	5.490	-53.485	-82.68	6.328	-67.59	-40.09	7.748	-75.36	-12.388
		(0.830)	(-0.452)	(-1.443)	(0.880)	(-0.437)	(-1.296)	(0.728)	(-0.387)	(-1.235)
	B_t	-0.06220	0.32392	0.7529	-0.0699	0.49946	0.4097	-0.07544	0.42542	0.12476
		(-1.773)*	(1.381)	(2.460)**	(-1.782)*	(1.371)	(2.334)**	(-1.670)*	(1.329)	(2.241)**
Computer and Peripheral Equipment	ΔRD_{t-1}	-0.1253	-1.2449	1.580	-0.1606	-1.5775	0.9798	-0.1803	-1.144	0.24876
		(-0.4644)	(-0.861)	(0.592)	(-0.402)	(-0.578)	(0.469)	(-0.436)	(-0.530)	(0.295)
	ΔTW_{t-1}	0.000532	-0.10135	-0.08693	0.000107	-0.11417	-0.03087	-0.00159	-0.07756	-0.00629
		(0.033)	(-0.240)	(-0.204)	(0.078)	(-0.277)	(-0.228)	(-0.042)	(-0.203)	(-0.134)
	ΔFP_{t-1}	-0.01337	0.04378	0.09028	-0.03078	0.07165	0.05181	-0.0406	0.46767	-0.07878
		(-0.610)	(0.389)	(0.200)	(-0.462)	(0.225)	(0.061)	(-0.508)	(0.363)	(-0.264)
	c	1.4781	-34.291	-34.67	1.398	-27.603	-15.897	0.6631	-29.54	-7.467
		(0.648)	(-0.328)	(-0.579)	(0.524)	(-0.454)	(-0.808)	(0.374)	(-0.259)	(-0.793)
	B_t	-0.01402	0.35045	0.3265	-0.01324	0.2844	0.14003	-0.00486	0.2929	0.07279
		(-1.651)*	(1.284)	(1.883)*	(-1.524)	(1.414)	(1.702)*	(-1.333)	(1.250)	(1.770)*
Optoelectronic	ΔRD_{t-1}	-0.15274	-0.3633	-1.6931	-0.1557	-0.3609	-0.6454	-0.1446	-0.364	-0.3802
		(-0.435)	(-0.181)	(-1.687)*	(-0.423)	(-0.081)	(-1.647)*	(-0.384)	(-0.231)	(-1.425)
	ΔTW_{t-1}	0.011236	-0.14031	0.2103	0.009162	-0.18918	0.0454	0.026515	-0.07179	0.07762
		(0.231)	(-0.344)	(1.800)*	(0.170)	(-0.427)	(1.623)	(0.279)	(-0.178)	(1.795)*
	ΔFP_{t-1}	-0.01354	-0.00627	-0.04676	-0.02349	0.05921	0.02984	-0.09716	-0.1334	-0.1120
		(-0.473)	(0.024)	(-0.047)	(-0.385)	(0.098)	(0.183)	(-0.521)	(-0.176)	(-0.138)
	c	-0.1771	1.127	-55.653	-1.516	1.268	-21.894	-1.651	-8.166	-8.0030
		(-0.023)	(0.134)	(-0.745)	(-0.230)	(0.017)	(-0.757)	(-0.306)	(-0.322)	(-0.404)
	B_t	0.00007	-0.01617	0.55526	0.01318	-0.01761	0.2180	0.01650	0.08102	0.077369
		(-0.004)	(-0.157)	(1.752)*	(0.194)	(-0.038)	(1.762)*	(0.334)	(0.307)	(1.401)
Communications and Internet	ΔTW_{t-1}	-0.0051	-0.3357	0.03005	-0.00066	-0.29286	0.02006	-0.00182	-0.47311	0.009512
		(-0.018)	(-1.791)*	(0.498)	(-0.124)	(-1.759)*	(0.487)	(-0.040)	(-2.336)**	(0.194)
	ΔFP_{t-1}	-0.0168	0.04862	-0.00375	-0.03515	0.1152	-0.1001	-0.13393	0.3638	-0.05773
		(-0.507)	(0.482)	(-0.008)	(-0.484)	(0.601)	(-0.114)	(-0.604)	(0.503)	(-0.143)
	c	-0.9273	-20.967	-44.73	-1.289	-21.252	-25.75	-1.033	-19.89	-5.652
		(-0.490)	(-0.430)	(-0.633)	(-0.465)	(-0.422)	(-0.651)	(-0.602)	(-0.371)	(-0.392)
	B_t	0.01138	0.1988	0.4489	0.01475	0.21462	0.2458	0.01274	0.20180	0.055998
		(1.473)	(1.436)	(1.614)	(1.450)	(1.431)	(1.642)*	(1.569)	(1.376)	(1.387)

Table 4 VAR (cont.)

Panel A. Number of patents in Taiwan (TW)

FP		ROE, model I			ROA, model II			EPS, model III		
		ΔRD_t	ΔTW_t	ΔFP_t	ΔRD_t	ΔTW_t	ΔFP_t	ΔRD_t	ΔTW_t	ΔFP_t
Electronic Parts and Components	ΔRD_{t-1}	0.11547	-0.9885	-0.7375	0.08767	-0.966	-0.3907	0.13181	-0.8367	0.0610
		(0.272)	(-0.530)	(-0.0453)	(0.205)	(-0.542)	(-0.054)	(0.316)	(-0.578)	(0.065)
	ΔTW_{t-1}	-0.00164	-0.1972	0.05622	-0.00145	-0.2148	0.01174	-0.00154	-0.2279	0.008997
		(-0.204)	(-0.499)	(0.1318)	(-0.205)	(-0.516)	(0.189)	(-0.176)	(-0.542)	(0.145)
	ΔFP_{t-1}	-0.00107	-0.09428	-0.03852	0.001931	-0.15821	-0.08561	-0.005	-0.5409	-0.1904
		(-0.131)	(-2.008)**	(-0.037)	(-0.068)	(-1.952)*	(-0.221)	(-0.122)	(-1.946)*	(-0.387)
	c	0.9618	-5.5471	-59.602	1.0419	-5.928	-36.690	1.0134	-6.646	-9.434
		(0.095)	(-0.360)	(-1.252)	(0.099)	(-0.237)	(-1.129)	(0.098)	(-0.203)	(-1.044)
	B_t	-0.01061	0.0542	0.59013	-0.01185	0.05808	0.36999	-0.01188	0.0632	0.09633
		(-1.117)	(1.320)	(2.247)**	(-1.131)	(1.253)	(2.127)**	(-1.144)	(1.208)	(2.091)
Electronic Products Distribution	ΔRD_{t-1}	-0.2102	-5.663	5.755	-0.2431	-6.074	1.905	-0.2584	-7.675	-1.623
		(-0.751)	(-2.019)**	(0.167)	(-0.892)	(-2.362)**	(0.227)	(-0.817)	(-1.926)*	(-0.221)
	ΔTW_{t-1}	0.03266	0.3278	2.03	0.03164	0.2975	0.1033	0.03357	0.3812	0.3674
		(1.869)*	(1.871)*	(0.439)	(1.874)*	(1.871)*	(0.093)	(1.895)*	(1.807)*	(0.421)
	ΔFP_{t-1}	-0.00336	-0.1932	-0.9623	-0.01917	-0.8401	-0.8132	-0.02643	-1.358	-0.8688
		(-0.661)	(-3.799)**	(-1.541)	(-0.929)	(-4.314)**	(-1.278)	(-0.662)	(-2.701)**	(-0.936)
	c	4.905	55.78	178.1	5.346	48.68	46.39	5.599	79.56	7.046
		(1.096)	(1.244)	(0.324)	(1.289)	(1.244)	(0.363)	(1.074)	(1.211)	(0.058)
	B_t	-0.0503	-0.5642	-1.765	-0.05474	-0.4936	-0.4606	-0.05725	-0.8023	-0.06925
		(-2.123)**	(-2.257)**	(-1.320)	(-2.318)**	(-2.259)**	(-1.360)	(-2.096)**	(-2.219)**	(-1.057)
Other Electronic	ΔRD_{t-1}	-0.10845	-24.8049	4.643	-0.0936	-24.2928	3.06578	-0.07133	0.1073	0.46454
		(-0.302)	(-0.052)	(2.018)**	(-0.258)	(-0.155)	(1.920)**	(-0.205)	(0.074)	(1.486)
	ΔTW_{t-1}	0.000009	-0.00276	-0.02545	0.000009	0.001822	-0.00387	0.000224	0.00847	-0.00264
		(0.061)	(-0.013)	(0.175)	(0.075)	(-0.000)	(-0.054)	(0.020)	(0.026)	(0.651)
	ΔFP_{t-1}	0.000324	0.1759	-0.16728	0.017779	0.03487	-0.31523	0.02646	1.364	-0.21495
		(-0.054)	(1.347)	(-1.603)	(0.285)	(1.214)	(-1.918)**	(0.188)	(1.727)*	(-1.629)
	c	1.0329	63.17	-54.80	0.4699	67.90	-26.688	0.9360	26.08	-11.425
		(0.307)	(0.537)	(-1.414)	(0.253)	(0.563)	(-1.279)	(0.448)	(0.288)	(-1.148)
	B_t	-0.00843	-0.6402	0.5370	-0.00286	-0.6881	0.25740	-0.00704	-0.2688	0.11601
		(-1.273)	(-1.540)	(2.386)**	(-1.212)	(-1.546)	(2.253)**	(-1.408)	(-1.313)	(2.138)**

Panel B. Number of patents in China (CN)

FP		ROE, model IV			ROA, model V			EPS, model VI		
		ΔRD_t	ΔCN_t	ΔFP_t	ΔRD_t	ΔCN_t	ΔFP_t	ΔRD_t	ΔCN_t	ΔFP_t
Semiconductor	ΔRD_{t-1}	0.18250	0.263	-0.8570	0.2317	0.3849	-0.6083	0.193143	0.4688	-0.03354
		(0.549)	(0.327)	(-1.786)*	(0.676)	(0.389)	(-1.854)*	(0.538)	(0.425)	(-1.211)
	ΔCN_{t-1}	0.002767	-0.03878	0.06662	0.005561	-0.13149	0.001749	0.006751	-0.11564	0.000125
		(0.285)	(-0.104)	(0.167)	(0.417)	(-0.396)	(0.086)	(0.306)	(-0.328)	(-0.005)
	ΔFP_{t-1}	0.019625	.0.2735	-0.4807	0.028203	0.02548	-0.4472	0.10493	0.4959	-0.4486
		(1.546)	(0.210)	(-2.163)**	(1.429)	(0.228)	(-2.254)**	(1.621)	(0.389)	(-2.181)**
	c	4.123	-24.21	-100.45	3.188	-15.34	-46.50	3.122	-3.352	-15.603
		(0.949)	(-0.285)	(-1.038)	(0.921)	(-0.236)	(-1.439)	(0.786)	(-0.069)	(-1.177)
	B_t	-0.04172	0.2334	1.0112	-0.04141	0.1437	0.4785	-0.03048	0.03229	0.15786
		(-1.846)*	(0.259)	(2.070)**	(-1.878)*	(0.211)	(2.450)**	(-1.758)*	(0.062)	(2.182)**

Table 4 VAR (cont.)

Panel B. Number of patents in China (CN)										
FP		ROE, model IV			ROA, model V			EPS, model VI		
		ΔRD_t	ΔCN_t	ΔFP_t	ΔRD_t	ΔCN_t	ΔFP_t	ΔRD_t	ΔCN_t	ΔFP_t
Computer and Peripheral Equipment	ΔRD_{t-1}	-0.1271	-0.4753	0.07022	-0.7490	-0.514	0.2374	-0.09686	-0.6116	0.32277
		(-0.211)	(-0.160)	(-0.000)	(-0.154)	(-0.198)	(0.076)	(-0.156)	(-0.198)	(0.367)
	ΔCN_{t-1}	-0.00206	-0.17446	-0.11074	-0.00105	-0.210	-0.08340	0.001226	-0.17178	-0.02833
		(-0.023)	(-0.501)	(-0.494)	(-0.009)	(-0.381)	(-0.513)	(0.144)	(-0.424)	(-0.504)
	ΔFP_{t-1}	-0.01148	0.0610	0.07869	-0.02085	0.1114	-0.00497	-0.04018	0.1367	-0.00419
		(-0.382)	(0.282)	(0.164)	(-0.562)	(0.237)	(-0.018)	(-0.339)	(0.308)	(-0.061)
	c	1.4214	-15.847	-28.076	1.427	-17.07	-15.193	1.4339	-11.588	-3.306
		(0.390)	(-0.316)	(-0.826)	(0.440)	(-0.361)	(-0.882)	(0.325)	(-0.230)	(-0.586)
	B_t	-0.01197	0.17547	0.24750	-0.01232	0.18154	0.13969	-0.01217	0.13061	0.03014
		(-1.292)	(0.372)	(1.734)*	(-1.341)	(0.403)	(1.813)*	(-1.284)	(0.228)	(1.578)
Optoelectronic	ΔRD_{t-1}	-0.1614	-0.0632	-1.167	-0.16743	-0.05822	-0.9009	-0.12428	-0.04574	-0.1944
		(-0.576)	(-0.232)	(-1.261)	(-0.563)	(-0.203)	(-1.178)	(-0.374)	(-0.164)	(-1.459)
	ΔCN_{t-1}	0.00387	-0.09939	-0.05062	0.003753	-0.08646	-0.1800	0.004043	-0.00540	-0.00447
		(-0.007)	(-0.164)	(-0.091)	(-0.044)	(-0.140)	(-0.200)	(0.188)	(-0.007)	(0.104)
	ΔFP_{t-1}	-0.00778	0.02426	0.08189	-0.01144	0.03455	0.05375	-0.03712	0.04242	-0.1069
		(-0.356)	(0.182)	(0.167)	(-0.259)	(0.145)	(0.127)	(-0.280)	(-0.031)	(-0.164)
	c	1.249	-6.165	-64.63	0.9067	-6.084	-2.942	-0.923	-5.153	-6.251
		(0.077)	(-0.519)	(-1.030)	(0.049)	(-0.642)	(-1.005)	(-0.159)	(-0.398)	(-0.449)
	B_t	-0.01739	0.06123	0.61146	-0.01398	0.06047	0.02500	0.007629	0.0511	0.05244
		(-1.126)	(1.527)	(2.027)**	(-0.098)	(1.650)*	(1.979)**	(0.127)	(1.405)	(1.427)
Communications and Internet	ΔRD_{t-1}	0.002021	-0.644	0.9003	0.05470	-0.5125	0.3612	0.04668	-0.5268	-0.08414
		(0.004)	(-0.817)	(0.267)	(0.141)	(-0.725)	(0.168)	(0.119)	(-0.693)	(-0.111)
	ΔCN_{t-1}	-0.00461	-0.289	0.2083	-0.00479	-0.3161	0.05871	-0.00283	-0.3228	-0.02249
		(-0.292)	(-1.655)	(0.364)	(-0.252)	(-1.731)*	(0.304)	(-0.399)	(-1.785)*	(-0.166)
	ΔFP_{t-1}	-0.01592	-0.013	-0.03433	-0.02969	-0.01560	-0.07877	-0.09684	-0.04278	-0.08913
		(-0.432)	(-0.366)	(-0.092)	(-0.414)	(-0.302)	(-0.302)	(-0.488)	(-0.263)	(-0.432)
	c	-0.4551	-11.414	-7.544	-0.4336	-10.597	-7.561	-0.3913	-11.412	-1.375
		(-0.503)	(-0.228)	(-0.478)	(-0.486)	(-0.188)	(-0.698)	(-0.481)	(-0.211)	(-0.172)
	B_t	0.00439	0.11436	0.07397	0.00419	0.10931	0.07505	0.003687	0.11433	0.009335
		(0.563)	(0.234)	(0.471)	(0.547)	(0.195)	(0.695)	(0.542)	(0.216)	(0.188)
Electronic Parts and Components	ΔRD_{t-1}	0.09537	-0.1358	-0.8902	0.06938	-0.2029	0.01175	0.11053	0.006302	0.1588
		(0.273)	(-0.083)	(-0.052)	(0.190)	(-0.115)	(0.001)	(0.329)	(0.012)	(0.069)
	ΔCN_{t-1}	0.01756	-0.54127	-0.28403	0.004997	-0.53886	-0.18297	-0.00025	-0.54244	-0.04408
		(0.025)	(-2.569)	(-0.374)	(0.006)	(-2.464)**	(-0.395)	(-0.031)	(-2.368)**	(-0.485)
	ΔFP_{t-1}	-0.00274	0.02819	-0.20781	-0.00240	0.05459	-0.1937	-0.00307	0.1317	-0.26435
		(-0.109)	(0.381)	(-0.456)	(-0.045)	(0.319)	(-0.526)	(-0.015)	(0.428)	(-0.545)
	c	2.4051	-4.289	-53.706	2.5435	-3.764	-29.115	2.4818	-1.096	-9.152
		(0.622)	(-0.266)	(-1.050)	(0.635)	(-0.090)	(-0.998)	(0.649)	(-0.085)	(-0.982)
	B_t	-0.02344	0.045041	0.54377	-0.02621	0.039811	0.28066	-0.02576	0.05141	0.089696
		(-1.628)*	(1.257)	(2.070)**	(-1.641)*	(1.192)	(2.010)**	(-1.655)**	(1.166)	(2.010)**

Table 4 VAR (cont.)

Panel B. Number of patents in China (CN)

FP		ROE, model IV			ROA, model V			EPS, model VI		
		ΔRD_t	ΔCN_t	ΔFP_t	ΔRD_t	ΔCN_t	ΔFP_t	ΔRD_t	ΔCN_t	ΔFP_t
Electronic Products Distribution	ΔRD_{t-1}	-0.1838	-32.83	7.889	0.06872	-0.2342	0.05622	-0.2237	-40.51	-1.192
		(-0.633)	(-2.728)**	(0.230)	(0.177)	(-0.151)	(0.031)	(-0.6866)	(-2.548)	(-0.164)
	ΔCN_{t-1}	-0.00289	-1.354	0.272	0.002384	-0.5656	-0.11453	-0.00260	-1.302	0.05806
		(-0.528)	(-5.962)**	(0.421)	(-0.012)	(-1.509)	(-0.332)	(-0.475)	(-4.946)	(0.483)
	ΔFP_{t-1}	-0.00398	-0.7214	-0.932	-0.00252	0.03017	-0.20827	-0.02852	-5.122	-0.8278
		(-0.743)	(-3.244)**	(-1.473)	(-0.116)	(0.220)	(-0.554)	(-0.675)	(-2.525)	(-0.893)
	c	8.137	435.2	268.5	2.5948	-2.260	-27.84	8.715	535.5	20.97
		(2.142)**	(2.762)**	(0.599)	(0.649)	(-0.061)	(-0.979)	(1.814)*	(2.321)**	(0.199)
	B_t	-0.08224	-4.132	-2.708	-0.02638	0.02420	0.2757	-0.08806	-5.145	-0.2168
		(-2.176)**	(-2.637)**	(-0.607)	(-0.658)	(0.161)	(0.992)	(-1.836)*	(-2.233)**	(-0.206)
Other Electronic	ΔRD_{t-1}	-0.00179	-3.587	4.8265	0.02090	-2.945	3.3076	0.01142	-3.0588	0.60956
		(-0.026)	(-0.400)	(2.198)**	(0.054)	(-0.283)	(2.199)**	(0.012)	(-0.370)	(1.589)
	ΔCN_{t-1}	-0.00031	0.33430	-0.00416	-0.00029	0.33870	-0.00242	-0.00029	0.33823	0.001637
		(-0.190)	(1.573)	(-0.127)	(-0.095)	(1.566)	(-0.144)	(-0.177)	(1.540)	(0.401)
	ΔFP_{t-1}	0.018077	0.1695	-0.3365	0.050447	-0.1877	-0.4725	0.15643	0.7353	-0.35154
		(0.262)	(0.392)	(-1.938)*	(0.797)	(0.235)	(-2.231)**	(0.488)	(0.416)	(-1.807)*
	c	0.803748	60.84	-38.995	0.9236	60.87	-18.963	1.1247	62.20	-15.857
		(0.305)	(0.861)	(-0.880)	(0.371)	(0.845)	(-0.753)	(0.382)	(0.688)	(-1.128)
	B_t	-0.00719	-0.6255	0.38348	-0.00839	-0.6247	0.17850	-0.01093	-0.6305	0.156949
		(-0.281)	(-1.864)*	(1.848)*	(-0.347)	(-1.835)*	(1.714)*	(-0.328)	(-1.693)*	(2.112)**

Panel C. Number of patents in the U.S. (US)

FP		ROE, model VII			ROA, model VIII			EPS, model IX		
		ΔRD_t	ΔUS_t	ΔFP_t	ΔRD_t	ΔUS_t	ΔFP_t	ΔRD_t	ΔUS_t	ΔFP_t
Semiconductor	ΔRD_{t-1}	0.14579	0.02171	-1.0528	0.18450	0.01298	-0.64363	0.1501	0.00331	-0.05373
		(0.408)	(0.116)	(-1.725)*	(0.574)	(0.010)	(-1.935)*	(0.386)	(0.053)	(-1.279)
	ΔUS_{t-1}	0.001534	0.10410	-0.00694	0.003239	0.11652	-0.00803	0.00047	0.11954	-0.00246
		(0.350)	(0.277)	(-0.068)	(0.432)	(0.308)	(-0.091)	(0.298)	(0.338)	(-0.010)
	ΔFP_{t-1}	0.01453	0.02989	-0.4411	0.02237	0.06325	-0.4804	0.09715	0.1776	-0.5049
		(0.541)	(0.203)	(-2.202)**	(0.430)	(0.168)	(-2.322)**	(0.548)	(0.054)	(-2.227)**
	c	8.120	-16.982	-72.47	7.818	-23.602	-38.08	8.345	-20.695	-11.676
		(0.783)	(-0.437)	(-0.840)	(0.711)	(-0.518)	(-1.207)	(0.725)	(-0.471)	(-1.158)
	B_t	-0.08660	0.122151	0.7333	-0.08259	0.181328	0.3892	-0.10111	0.1580	0.11823
		(-1.770)*	(0.457)	(1.851)*	(-1.711)*	(0.507)	(2.238)**	(-1.718)*	(0.462)	(2.172)**
Computer and Peripheral Equipment	ΔRD_{t-1}	-0.1309	-0.3417	0.8331	-0.15665	-0.3894	0.4427	-0.14838	-0.4306	0.16968
		(-0.266)	(-0.365)	(0.101)	(-0.355)	(-0.292)	(0.159)	(-0.302)	(-0.206)	(0.211)
	ΔUS_{t-1}	0.010537	-0.151	-0.08886	0.01256	-0.1590	-0.08617	0.010619	-0.20681	-0.01621
		(0.651)	(-0.443)	(-0.073)	(0.619)	(-0.386)	(-0.299)	(0.622)	(-0.462)	(-0.197)
	ΔFP_{t-1}	-0.00629	-0.00479	0.07824	-0.01178	-0.00335	0.08795	-0.03421	-0.00755	0.01565
		(-0.294)	(-0.023)	(0.178)	(-0.324)	(-0.029)	(0.160)	(-0.480)	(0.017)	(0.005)
	c	0.9062	-6.668	-44.18	0.8273	-7.515	-18.25	0.5895	-7.551	-5.705
		(0.354)	(-0.380)	(-0.612)	(0.351)	(-0.378)	(-0.672)	(0.164)	(-0.371)	(-0.670)
	B_t	-0.00802	0.06779	0.4344	-0.00724	0.07642	0.1767	-0.00455	0.07761	0.05388
		(-0.300)	(0.355)	(1.604)	(-0.298)	(0.375)	(1.651)*	(-0.107)	(0.366)	(1.636)*

Table 4 VAR (cont.)

Panel C. Number of patents in the U.S. (US)										
FP		ROE, model VII			ROA, model VIII			EPS, model IX		
		ΔRD_t	ΔUS_t	ΔFP_t	ΔRD_t	ΔUS_t	ΔFP_t	ΔRD_t	ΔUS_t	ΔFP_t
Optoelectronic	ΔRD_{t-1}	-0.17330	0.2357	-1.388	-0.18856	0.2342	-0.7600	0.03037	0.3249	-0.3392
		(-1.558)	(0.160)	(-1.472)	(-1.560)	(0.148)	(-0.332)	(1.126)	(0.488)	(-1.717)*
	ΔUS_{t-1}	0.005152	-0.09712	0.191	0.002953	-0.08121	0.06113	0.009126	-0.2209	-0.00524
		(0.052)	(-0.091)	(0.187)	(0.016)	(-0.125)	(0.0689)	(0.087)	(-0.310)	(0.107)
	ΔFP_{t-1}	-0.01417	0.003644	-0.053	-0.02554	0.01216	-0.06148	-0.08601	0.1693	-0.1287
		(-0.629)	(0.087)	(-0.105)	(-0.552)	(0.107)	(-0.115)	(-0.698)	(0.592)	(-0.254)
	c	2.765	-22.906	-54.206	2.565	-31.039	-28.127	1.028	-15.525	-5.321
		(0.366)	(-0.299)	(-0.704)	(0.451)	(-0.401)	(-0.661)	(0.180)	(-0.524)	(-0.492)
	B_t	-0.02823	0.22898	0.54038	-0.02556	0.31113	0.27295	-0.01075	0.15619	0.05198
		(-0.370)	(0.289)	(1.704)*	(-0.461)	(0.390)	(1.663)*	(-0.186)	(0.509)	(1.489)
Communications and Internet	ΔRD_{t-1}	-0.04129	-0.5114	0.02968	-0.1037	-0.5813	-0.3464	-0.05096	-0.5551	-0.01876
		(-0.102)	(-0.474)	(0.019)	(-0.213)	(-0.356)	(-0.169)	(-0.114)	(-0.195)	(-0.091)
	ΔUS_{t-1}	0.02503	-0.3932	-0.1615	0.02469	-0.3890	-0.08395	0.02511	-0.3626	0.01108
		(0.220)	(-1.942)*	(-0.091)	(0.214)	(-1.923)*	(-0.095)	(0.246)	(-1.742)*	(0.061)
	ΔFP_{t-1}	-0.01743	0.005975	0.06234	-0.04149	0.02194	0.038988	-0.15827	0.14112	0.020327
		(-0.379)	(0.051)	(0.160)	(-0.382)	(0.081)	(0.084)	(-0.666)	(0.272)	(0.122)
	c	-2.902	-8.676	-14.08	-2.868	-8.601	-12.702	-2.807	-6.650	-1.980
		(-0.678)	(-0.474)	(-0.530)	(-0.642)	(-0.478)	(-0.513)	(-0.640)	(-0.547)	(-0.184)
	B_t	0.02775	0.08278	0.1397	0.02741	0.08635	0.12662	0.02680	0.06327	0.01456
		(1.724)*	(0.334)	(0.516)	(1.689)*	(0.443)	(0.495)	(1.687)*	(0.537)	(0.149)
Electronic Parts and Components	ΔRD_{t-1}	0.1676	-0.1264	-0.3695	0.1703	-0.1910	-0.00281	0.17772	-0.1489	-0.02234
		(0.394)	(-0.283)	(-0.052)	(0.337)	(-0.304)	(-0.001)	(0.393)	(-0.318)	(-0.025)
	ΔUS_{t-1}	0.002469	-0.4756	-0.28721	0.002468	-0.4853	-0.13775	-0.00288	-0.4599	-0.07934
		(0.025)	(-2.391)	(-0.184)	(0.006)	(-2.392)**	(-0.144)	(-0.032)	(-2.355)**	(-0.176)
	ΔFP_{t-1}	-0.00274	0.006934	-0.11425	-0.00264	0.009855	-0.1939	-0.00119	0.06105	-0.26748
		(-0.109)	(0.325)	(-0.273)	(-0.127)	(0.362)	(-0.467)	(-0.048)	(0.455)	(-0.545)
	c	1.8773	-1.787	-52.467	1.9022	-1.664	-35.288	1.8766	-1.096	-9.7595
		(0.513)	(-0.125)	(-1.001)	(0.518)	(-0.114)	(-0.961)	(0.512)	(-0.103)	(-0.982)
	B_t	-0.01918	0.01772	0.52966	-0.01940	0.008579	0.35529	-0.01917	0.00829	0.101066
		(-0.521)	(0.059)	(1.990)**	(-0.526)	(0.022)	(1.943)*	(-0.520)	(0.028)	(2.010)**
Electronic Products Distribution	ΔRD_{t-1}	-0.2725	-3.206	-3.581	-0.2817	-3.355	0.03364	-0.3641	-2.607	-3.914
		(-0.839)	(-0.661)	(-0.094)	(-0.897)	(-0.700)	(0.004)	(-0.989)	(-0.468)	(-0.477)
	ΔUS_{t-1}	0.02049	0.05664	2.493	0.01635	0.03931	0.493	0.02538	0.05011	0.4839
		(0.608)	(0.113)	(1.635)	(0.486)	(0.076)	(1.511)	(0.766)	(0.100)	(1.656)*
	ΔFP_{t-1}	-0.00316	-0.00321	-0.9278	-0.01762	-0.05347	-0.7371	-0.02986	0.1058	-0.9329
		(-0.598)	(-0.041)	(-1.506)	(-0.791)	(-0.157)	(-1.154)	(-0.731)	(0.171)	(-1.024)
	c	6.984	0.1038	280.8	7.326	4.713	39.54	8.136	-12.03	35.03
		(1.940)*	(0.002)	(0.670)	(2.195)**	(0.093)	(0.413)	(1.816)*	(-0.178)	(0.351)
	B_t	-0.07123	-0.00547	-2.809	-0.07466	-0.05172	-0.3949	-0.08282	0.1165	-0.3528
		(-1.978)**	(-0.010)	(-0.669)	(-2.237)**	(-0.101)	(-0.413)	(-1.844)*	(0.172)	(-0.353)

Table 4 VAR (cont.)

Panel C. Number of patents in the U.S. (US)										
FP		ROE, model VII			ROA, model VIII			EPS, model IX		
		ΔRD_t	ΔUS_t	ΔFP_t	ΔRD_t	ΔUS_t	ΔFP_t	ΔRD_t	ΔUS_t	ΔFP_t
Other Electronic	ΔRD_{t-1}	-0.07887 (-0.229)	-2.3313 (-0.354)	2.9741 (1.893)*	-0.05320 (-0.149)	-2.4756 (-0.359)	2.0103 (1.870)*	-0.05160 (-0.152)	-2.5170 (-0.250)	0.3202 (1.379)
	ΔUS_{t-1}	0.000060 (-0.067)	0.12644 (0.306)	0.1219 (0.118)	0.00006 (-0.097)	0.14058 (0.341)	0.084072 (0.284)	0.000172 (0.044)	0.10624 (0.288)	0.01676 (0.426)
	ΔFP_{t-1}	-0.00328 (-0.340)	0.13116 (0.362)	-0.24414 (-1.720)*	0.003673 (-0.160)	0.2468 (0.436)	-0.32534 (-1.797)*	-0.00557 (-0.314)	1.974 (0.605)	-0.17814 (-1.386)
	c	1.9464 (0.800)	33.267 (0.385)	-54.63 (-1.600)	1.0642 (0.833)	35.931 (0.496)	-22.94 (-1.506)	1.805 (0.996)	27.821 (0.141)	-23.044 (-1.262)
	B_t	-0.01765 (-0.788)	-0.30179 (-0.390)	0.5383 (2.572)**	-0.01022 (-0.824)	-0.3337 (-0.496)	0.2182 (2.479)**	-0.01603 (-0.984)	-0.27806 (-0.144)	0.23285 (2.251)**

Notes:

1. Table 4 presents the median of each estimated coefficient in the VAR models by industry type. For each firm, we have nine VAR models, *i.e.*,

$$RD_t = a_1 + \sum_{l=1}^{m} b_{1,l} RD_{t-l} + \sum_{l=1}^{m} c_{1,l} PT_{t-l} + \sum_{l=1}^{m} f_{1,l} FP_{t-l} + g_1 B_t + \varepsilon_{1,t}$$

$$PT_t = a_2 + \sum_{l=1}^{m} b_{2,l} RD_{t-l} + \sum_{l=1}^{m} c_{2,l} PT_{t-l} + \sum_{l=1}^{m} f_{2,l} FP_{t-l} + g_2 B_t + \varepsilon_{2,t}$$

$$FP_t = a_5 + \sum_{l=1}^{m} b_{5,l} RD_{t-l} + \sum_{l=1}^{m} c_{5,l} PT_{t-l} + \sum_{l=1}^{m} f_{5,l} FP_{t-l} + g_5 B_t + \varepsilon_{3,t}$$

where RD_t is the ratio of R&D expenditures to sales in year t, PT_i is number of patents obtained in Taiwan, China, and the U.S. (i.e., TW_t, CN_t, and US_t, respectively), in year t, FP_t is financial performance (*i.e.*, ROA_t, ROE_t, and EPS_t, respectively) in year t, B_t is the business cycle index, and m is the maximum number of lag terms of each variable, and ε is supposed to be a white noise.

2. The symbol * and ** denotes for significance at the 10% and 5% level, respectively.

5 Summary and conclusions

In this study, we investigate the relationships among R&D, number of patents, and financial performances for the firms listed on the TWSE. In particular, we apply Unit Root Tests and VAR models to examine the relationships of the listed firms classified as industries of Semiconductor, Computer and Peripheral Equipment, Optoelectronic, Communications and Internet, Electronic Parts & Components, Electronic Products Distribution, and Other Electronic, by the TWSE. In sum, the empirical results find the different lead-lag relationships among R&D, patent arrangements, and financial performances in different industries, indicating important insight into patent arrangements.

Acknowledgements

The authors appreciate the precious comments and suggestions from Professor Mihaly Ormos, Professor Tamás Jónás, the anonymous referees, and other participants at the SSEM EuroConference 2014, Budapest University of Technology and Economics, Budapest, Hungary. All errors are the authors' responsibility.

References

Agrawal, A., Knoeber, C. R. (1996) Firm performance and mechanisms to control agency problems between managers and shareholders. *Journal of Financial and Quantitative Analysis*. 31 (3). pp. 377-397. DOI: 10.2307/2331397

Ashton, W. B., Sen, R. K. (1989) Using patent information in technology business planning. *Research-Technology Management*. 32 (1). pp. 36-42.

Beneito, P. (2006) The innovative performance of in-house and contracted R&D in terms of patents and utility models. *Research Policy*. 35 (4). pp. 502–517. DOI: 10.1016/j.respol.2006.01.007

Ben-Zion, U. (1978) The investment aspect of nonproduction expenditures: An empirical test. *Journal of Economics and Business*. 30 (3). pp. 224-229.

Bessler, W., Bittelmeyer, C. (2008) Patents and the performance of technology firms: Evidence from initial public offerings in Germany. *Financial Markets Portfolio Management*. 22. pp. 323–356.

Bharadwaj, A. S., Bharadwaj, S. G., Konsynski, B. R. (1999) Information technology effects on firm performance as measured by Tobin's Q. *Management Science*. 45 (7). pp. 1008-1024. DOI: 10.1287/mnsc.45.7.1008

Bloom, N., Reenen, J. V. (2002) Patents, real options and firm performance. *Economic Journal*. 112 (478). pp. 97-116. DOI: 10.1111/1468-0297.00022

Chen, Y.-S., Chang, K.-C. (2010) Exploring the nonlinear effects of patent citations, patent share and relative patent position on market value in the US pharmaceutical industry. *Technology Analysis and Strategic Management*. 22 (2). pp. 153-169. DOI: 10.1080/09537320903498496

Chiu, Y.-C., Liang, C.-W., Wang, Y. (2012) Corporate financing decisions on research and development increases. *Emerging Markets Finance and Trade.* 48 (1). pp. 88-109. DOI: 10.2753/ree1540-496x4801s107

Chung, K. H., Pruitt, S. W. (1996) Executive ownership, corporate value, and executive compensation: A unifying framework. *Journal of Banking and Finance*. 20 (7). pp. 1135-1159. DOI: 10.1016/0378-4266(95)00039-9

Cockburn, I., Griliches, Z. (1988) Industry effects and Appropriability Measures in the Stock Markets Valuation of R&D and Patents. *American Economic Review.* 78 (2). pp. 419-423. DOI: 10.3386/w2465

Crepon, B., Duguet, E., Mairessecc, J. (1998) Research, innovation and productivity: An econometric analysis at the firm level. *Economics of Innovation and New Technology*. 7 (2), pp. 115-158. DOI: 10.3386/w6696

Edvinsson, L. (1997) Developing intellectual capital at Skandia. *Long Range Planning*. 30 (3). pp. 366-373. DOI: 10.1016/s0024-6301(97)00016-2

Edvinsson, L., Malone, M. S. (1997) *Intellectual capital: Realizing your company's true value by finding its hidden brainpower*. New York: Harper Collins.

Ernst, H. (1995) Patenting strategies in the German mechanical engineering industry and their relationship to company performance. *Technovation*. 15 (4). pp. 225–240. DOI: 10.1016/0166-4972(95)96605-s

Griliches, Z. (1981) Market value, R&D and patent. *Economics Letters*. 7 (2). pp. 183-187.

Griliches, Z. (1998) Patent statistics as economic indicators: A survey. *Journal of Economic Literature*. 28. pp. 1661-1707.

Griliches, Z., Hall, B. H., Pakes, A. (1991) R&D, patents, and market value revisited: Is there a second (technological opportunity) factor?. *Economics of Innovation and New Technology.* 1 (3). pp. 183-201. DOI: 10.1080/10438599100000001

Grupp, H., Schmoch, U. (1999) Patent statistics in the age of globalisation: New legal procedures, new analytical methods, new economic interpretation. *Research Policy*. 28 (4). pp. 377–396. DOI: 10.1016/s0048-7333(98)00125-5

Hall, B. H., Jaffe, A., Trajtenberg, M. (2005) Market value and patent citations. *RAND Journal of Economics*. 36 (1). pp. 16-38.

Hall, L. A., Bagchi-Sen, S. (2002) A Study of R&D, innovation, and business performance in the Canadian biotechnology industry. *Technovation*. 22 (4). pp. 231–244. DOI: 10.1016/s0166-4972(01)00016-5

Hirschey, M., Weygandt, J. J. (1985) Amortization policy for advertising and research and development expenditures. *Journal of Accounting Research*. 23 (1). pp. 326-335. DOI: 10.2307/2490921

Hitt, M. A., Hoskisson, R. E., Ireland, R. D., Harrison, J. S. (1991) Effects of acquisitions on R&D inputs and outputs. *Academy of Management Journal*. 34 (3). pp. 693-706. DOI: 10.2307/256412

Horrigan, J. O. (1965) Some empirical bases of financial ratio analysis. *Accounting Review*. 40. pp. 558-568.

Howkins, J. (2001) *The creative economy: How people make money from ideas*. NY: Penguin.

Hsu, F.-J., Chen, M.-Y., Chen, Y.-C., Wang, W.-C. (2013) An empirical study on the relationship between R&D and financial performance. *Journal of Applied Finance and Banking.* 3 (5). pp. 107-119.

Huang, H.-H., Hsu, P., Khan, H. A., Yu, Y.-L. (2008) Does the appointment of an outside director increase firm value? Evidence from Taiwan. *Emerging Markets Finance and Trade*. 44 (3). pp. 66-80. DOI: 10.2753/ree1540-496x440305

Jaffe, A. B., Trajtenberg, M. (1999) International knowledge flows: Evidence from patent citations. *Economics of Innovation and New Technology*. 8, pp. 105-136. DOI: 10.1080/10438599900000006

Kelley, D. J., Rice, M. P. (2002) Advantage beyond founding: The strategic use of technologies. *Journal of Business Venturing*. 17 (1). pp. 41-57. DOI: 10.1016/s0883-9026(00)00053-7

Lanjouw, J. O., Pakes, A., Putnam, J. (1998) How to count patents and value intellectual property: The uses of patent renewal and application data. *Journal of Industrial Economics*. 46 (4). pp. 405-432. DOI: 10.3386/w5741

Lantz, J.-S., Sahut, J.-M. (2005) R&D investment and the financial performance of technological firms. *International Journal of Business*. 10 (3). pp. 251-270.

Levitas, E., Chi, T. (2010) A look at the value creation effects of patenting and capital investment through a real options lens: The moderating role of uncertainty. *Strategic Entrepreneurship Journal*. 4 (3). pp. 212-233. DOI: 10.1002/sej.92

Lilien, G., Yoon, E. (1989) Determinants of new industrial product performance: A strategic reexamination of the empirical literature. *IEEE Transactions on Engineering Management.* 36 (1). pp. 3-10. DOI: 10.1109/17.19976

Madanmohan, T., Kumar, U., Kumar, V. (2004) Import-led technological capability: A comparative analysis of Indian and Indonesian manufacturing firms. *Technovation*. 24 (12). pp. 979-993. DOI: 10.1016/s0166-4972(03)00030-0

McKelvey, B. (1982) *Organizational systematics: Taxonomy, evolution, classification*. Berkeley. California: University of California.

Megna, P., Klock, M. (1993) The impact of intangible capital on Tobin's Q in the semiconductor industry. *American Economic Review*. 83 (2). pp. 265-269.

Narin, F., Noma, E. (1987) Patents as indicators of corporate technological strength. *Research Policy*. 16. pp. 143-155. DOI: 10.1016/0048-7333(87)90028-x

Nelson, R. R. (1982) The role of knowledge in R&D efficiency. *Quarterly Journal of Economics*. 97 (3). pp. 453-470. DOI: 10.2307/1885872

Neuhäusler, P., Frietsch, R., Schubert, T., Blind, K. (2011) *Patents and the financial performance of firms - An analysis based on stock market data*. Fraunhofer ISI Discussion Papers Innovation Systems and Policy Analysis 28.

Pakes, A. (1985) „On patents, R&D, and the stock market rate of return." *Journal of Political Economy.* 93 (2). pp. 390-409. DOI: 10.1086/261305

Pakes, A., Griliches, Z. (1980) Patents and R&D at the firm level: A first report. *Economics Letters*. 5 (4). pp. 377-381. DOI: 10.1016/0165-1765(80)90136-6

Richardson, F. M., Kane, G. D., Lobingier, P. (1998) The impact of recession on the prediction of corporate failure. *Journal of Business Finance and Accounting.* 25. pp. 167-186. DOI: 10.1111/1468-5957.00182

Schmookler, J. (1966) *Invention and economic growth*. Cambridge, MA: Harvard University Press.

Skinner, D. J. (1993) The investment opportunity set and accounting procedure choice: Preliminary evidence. *Journal of Accounting and Economics*. 16 (4). pp. 407-445. DOI: 10.1016/0165-4101(93)90034-d

Sougiannis, T. (1994) The accounting based valuation of corporate R&D. *Accounting Review*. 69 (1). pp. 44-68.

Sundaram, A. K., John, T. A., John, K. (1996) An empirical analysis of strategic competition and firm values: The case of R&D competition. *Journal of Financial Economics*. 40 (3). pp. 459-486. DOI: 10.1016/0304-405x(95)00853-7

Tobin, J. (1978) *Cowles foundation for research in economics*. New Haven: Yale University.

Toivanen, O., Stoneman, P., Bosworth, D. (2002) Innovation and the market value of UK firms, 1989–1995. *Oxford Bulletin of Economics and Statistics.* 64 (1). pp. 39-61. DOI: 10.1111/1468-0084.00002

Wernerfelt, B., Montgomery, C. A. (1988) Tobin's Q and the importance of focus in firm performance. *American Economic Review*. 78 (1). pp. 246-250.