Essential Patent Indicators for the Evaluation of Industrial Technological Innovation Competitiveness

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Abstract
This article aims to develop essential patent indicators for evaluating the technological innovation competitiveness between industrials or companies. Citations of certain patent cited by specific company and cited year both contribute to meaningful evaluation outcomes. A novel indicator for representing an industrial's patent performance, Essential Patent Index (EPI), was developed first by setting weight factors on who cited these patents and when these patents were cited. By combining EPI and Chi's well-known Technological Strength (TS) indicator, a second novel indicator Essential Technological Strength (ETS) was developed to represent a company's innovation competitiveness. In this case study, patent performances of three high-tech industries in Taiwan were analyzed using ETS as well as the traditional TS for comparison. Results from this analysis demonstrated that ETS provided better insights by clearly verifying the latent influence of citations, enforcing the impact of essential patents, and aggrandizing the innovation competitiveness differences between companies.

Introduction
In the era of knowledge economy, the force of company/institute innovation and R&D capacity will decide its competitive status on the international market. The innovation and R&D capacity would also replace land, labors and even the capital assets to become the major driving forces for economic growth (Wu, 2000). Therefore, in addition to the indices of company income, growth rate, and profit, etc., analysis of innovation and R&D capacity indicators can provide a more accurate estimation of company's overall performance. Generally speaking, innovation and R&D budget, R&D manpower, cooperation between industry and academic sector, as well as R&D output have all been used as indicators for comparison. Besides these indicators, company's achievement on intellectual properties such as patents owned could be the most straightforward one for evaluation (Chen, et al., 2003).

According to the Global Competitiveness Report 2004-2005 (World Economic Forum, 2004) by World Economic Forum, Taiwan's Growth Competitiveness Index ranks number 4. The most eye-catching performance by Taiwan is on the Technology Index item where Taiwan scores number two on the world behind the United States. Among the several subindexes including innovation, technology transfer, and information & communication technology used for evaluating the Technology Index, innovation such as granted utility patents in the United States played a major role as hard data for evaluating the national competitiveness. Therefore, evaluating the company performance on patent output is without a doubt the most effective and direct measurement on their R&D ability, innovation force and technology competitiveness.

Over the past decades, increasing interests on patent information analysis to be used on technological innovation competitiveness had become quite popular among academic scientists. When patent activities being treated as reflection of technological force, several indicators such as number of patents, patent growth rate, and Activity Index (AI), etc., to quantitatively evaluate the performance of industrials or countries (Albert, et al., 1998; Garg and Padhi, 1998; Narin, et al., 2000). With more patent information available, this kind of analysis is gradually involved into current industrial competition strategies. The industrialists and national policy makers pay more attention on several aspects such as how to control and predict the development of key technologies, the distribution of competitors, competitive and cooperative strategies, and hunting of important inventors. For example, from the viewpoint of market value, citation-weighted patent stocks are highly correlated with market

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value than patent stocks themselves that this fact is due mainly to the high valuation placed on firms that hold very highly cited patents (Hall, et al., 2000).

In these trends, the quantity analysis no longer satisfies the comprehensive needs. Quality indicators therefore have been developed to meet the demands with the help of developed patent system, availability of machine-readable form, and benefit of information technology. Patent quality indicators analyze patent cites and cited data. For example, Patent Citation Number is an analysis on the influence of a specific organization's patent output to other organizations. CII is to analyze the cited number and the ratio of the patents the company owns; the higher cited number is a sign that the cited patent represents an important technological advance somehow means better quality (Breitzman and Narin, 2001). Other indicators focus on identifies patent characteristics and show the national or industry technology characters by analyzing the type of the documents that patent cited and the gap of the citation years. For example, Science Linkage can be used to reveal the relationship between the fundamental science and patent technology through the scientific papers and non-scientific papers and understand the character of the industry technology (Narin and Olivastro, 1998). Technology Cycle Time is used to analyze the median of the age's gap of the cited patents and this index can measure the cycle time of patent technology exchange. (Narin, et al., 2000)

With more developed indicators available nowadays, organizations started to measure innovative performance by using multiple indicators (Hagedoorn and Cloodt, 2003). Among several international ranking reports, TR Patent Scorecard Report, which published by MIT Technology Review and CHI Research Inc. annually, is one of the most authoritative reports. TR Patent Scorecard Report ranks the United States patent portfolios of 150 top technology companies in eight sectors including aerospace, automotive, biotechnology/pharmaceuticals, chemicals, computers, electronics, semiconductors and telecommunications (Technology Review and CHI Research, 2004). Items such as Number of Patents, Current Impact Index, Science Linkage, Technology Cycle Time and Technological Strength are included in this patent analyses report. Finally, companies were ranked according to their "Technology Strength".

TR Patent Scorecard Report focuses all its attention on the overall performance of technology strength but innovation forces. In the perspective of technology competitiveness, innovation might carry the great weight of R&D efforts. This article is not only analyzed technological strength but also innovation competitiveness. Patent counts, current impact, and technology strength taken together as an indicator of company technology force. Based on this, we put the accent on newest granted patents that are cited in short period and define them as essential patents by giving weight in indicator. The most internationalized industries in Taiwan, semiconductor, computer system, and computer peripheral and part have been chosen to be cases to do the comparison of indicator ranking. The purpose of this research is to raise the fact that each citation is unique and should not be treated under the same value.

Methodology：Indicators

This research used quantitative and qualitative perspectives to thoroughly investigate the impact of company patents in different industry. In the technological competitiveness, we adopt the indicators from TR Patent Scorecard. For evaluating the innovation force, we created two new indicators, Essential Patent Index and Essential Technology Strength.

Number of Patents

Number of Patents is the basic information for evaluation. Gathering statistical pattern and analyzing granted number of patents can reveal the development profile and trend in a specific industry. For example, number of granted patents of Taiwan industries in 2003 by the US Patent and Trademark Office (USPTO) will be collected in this study. This indicator helps to evaluate the industry development profile in the quantitative viewpoint. By comparing the number of patents in certain years, the patent granted trend in this period would be revealed. In this study, term P_{ij} represents the number of granted patents by company i in industry j.

Current Impact Index, CII

CII for a particular company is evaluated based on the number of times patents issued this year cite the patents issued to the chosen company divided by the number of patents issued to the company in each of the previous five years. In order to produce an average citation rate, this previous ratio is then divided by the average citation rate for all patents issued in each year during the same time period. The net result of this analysis is the CII (Breitzman and Narin, 2001). When the CII value is greater than 1.0, it means that granted patents owned by certain company have been cited frequently than average, and it has better patent quality and its technology has greater impact on the that industry technology development. In this study, we used the average cited number in 2003 of each patent and compared it to the average value from 1998 to 2002 for evaluating CII, the equation of CII_{ij} is given by:

$$CII_{ij} = \frac{C_{ij} / K_{ij}}{\sum_i C_{ij} / \sum_i K_{ij}} \tag{1}$$

where C_{ij} represents the cited number of patents in certain year, and company i produced in industry j from previous five years, K_{ij} is the number of patents, company i produced in industry j from previous five years.

Technological Strength, TS

Number of Patents shows a company's R&D investment and output and CII represents the company's importance in the technology domain by their citation situation (Breitzman and Narin, 2001). TS of i company in j industry, TS_{ij} , can be computed by its number of patents and its CII as follow,

$$TS_{ij} = P_{ij} \times CII_{ij} \tag{2}$$

Essential Patent Index, EPI

Searching the total cited number of patents that are owned by all companies in one industry in a certain period can identify the impact of patent. The higher cited number means the greater impact. Since the citations caused by different objects represent various meaning and value, the company-weighted should be considered in the company relation network. Beside, the cited number is easily influenced by the factor of age. It means the older patent has higher cited probability. Therefore, each citation by specific assignee in different age seniority is unique and should not be treated under the same value if the innovation competitiveness has to be identified clearly. Base on the above discussion, we have

Axiom 1: The citation comes from an important assignee is carrying more influences.

$$\Psi_s = \prod_{a=1}^{A_s} {\psi_{a,s}}^{n_{a,s}} \tag{3}$$

where $\psi_{a,s}$ is the weighted factor of assignee company a which cite patent s, A_s is the total number of companies which cite patent s, and $n_{a,s}$ is the total citing number of patent s by company a.

Axiom 2: The cited number of patent will increase after it was granted for years. The citation appears in early period has its importance and the influence and somehow age is in negative association with cited number.

$$W_{z,q} = \frac{{E_{z,q}}^{-1}}{\sum_{q=0}^{Q_z} {E_{z,q}}^{-1}} \tag{4}$$

where $E_{z,q}$ is the total number of patents granted in year z which are cited in year $z+q$.

The essential integration G_s is derived from the factor $W_{z,q}$ and Ψ_s and the equation is given by,

$$G_s = \sum_{q=0}^{q_{max}} (W_{z,q} \times e_{s,z,q}) \times \Psi_s \quad (5)$$

where $e_{s,z,q}$ is the total cited number of patents *s* (granted in year *z*) in year *z+q*.
Based on the ranking and integration G_s, this research defined the essential patents as the top 25% patents. The integration was computed by the age difference as the weighting number, counted the corporation essential patent number and the ratio of essential patent, then, normalized them. EPI can evaluate the number and importance of core technology that patent assignee has in one industry. EPI of *i* company in *j* industry, EPI_{ij}, can be computed by its number of patents and number of patents as follow,

$$EPI_{ij} = \frac{EPN_{ij} / P_{ij}}{0.25} \quad (6)$$

where EPN_{ij} represent the number of essential patents by *i* company in *j* industry.

Essential Technological Strength, ETS
ETS evaluates the company performances in specific industry by Number of Patents, CII and EPI in certain year. The difference with TS is to combine EPI which shows the corporation essential technology status and reflect truly the strength and weakness of the patent performance, and know well the important key technology owners. The ETS of *i* company in *j* industry, ETS_{ij}, can be computed by its number of patents, EPI, and CII as follow,

$$ETS_{ij} = P_{ij} \times EPI_{ij} \times CII_{ij} \quad (7)$$

Case Study: Technological Innovation Competitiveness Analysis of High-Tech Industries in Taiwan
Three high-tech industries in Taiwan, semiconductor, computer system, and computer peripheral and parts, were selected by this study. The performances of ETS on evaluating technological innovation were tested following by examining the performance difference between TS and ETS.

This analysis searched the utility patent granted in USPTO database. Country of assignee is applied as Taiwan and the year of issue date is set as 2003 and then selected out the top seventy assignees. Since the data in USPTO database is in English, names of Taiwan assignee do not have a uniform format and many companies had been merged or independent from a cooperative, so this study takes the authority control to the assignee name before any statistics and analysis have been processed.

There are two parts of patent search; the first one is on the performance of the total number of patents of targeted Taiwan industries. The number of patents from the top seventy assignees in 2003 and their averages from 1998 to 2002 were collected. All types of patent, utility and design, are included. Therefore, the search strategy here is "all patents of the top seventy Taiwan patent assignees in the USA from 1998 to 2003". Table 1 summarized the number of patents results as an indication of overall R&D output profile of Taiwan company/institute.

For evaluating the competitiveness of enterprises, the second step was to remove four non-profit assignees, Industrial Technology Research Institute, Taiwan National Science Council, Chung Shan Institute of Science and Technology, and Academia Sinica, from the result of first-step search. Then, the 66 companies left were further classified according to their attributes of product. The purpose of this classification is to allocate the similar companies together and make sure the competition criteria would be even. Semiconductor, computer system, and computer peripheral and parts are the most internationalize industries in Taiwan; they are also been defined as high-tech industries by the government of Taiwan as well as carry the most expectation. Since number of utility patents granted is strongly correlated to a company's R&D and competition capabilities, only utility number of patents of each company was collected from the database. In summary, the search strategy of the second part is "the granted utility patents of every company in three industries in the USA from 1998 to 2003. The weight factor of assignee company $\psi_{a,s}$ is been set as 1 in this case.

Table 1. Number of patents of Taiwan companies/institutes (2003, granted).

Company / Institute	Rank (No. of Patents) 2003	Rank (No. of Patents) '98-'02 Avg.	Company / Institute	Rank (No. of Patents) 2003	Rank (No. of Patents) '98-'02 Avg.
Hon Hai Precision Ind. Co.	1 (483)	3 (272.4)	Darfon Electronics Co.	36 (16)	21 (5.4)
Taiwan Semiconductor Manufacturing Co.	2 (434)	1 (428.6)	Academia Sinica	37 (14)	28 (7.8)
Industrial Technology Research Institute, Taiwan	3 (207)	4 (211.6)	Compal Electronic, Inc.	38 (14)	19 (14.6)
United Microelectronic Corp.	4 (188)	2 (398.2)	Faraday Technology Corp.	39 (14)	45 (3.8)
Macronix International Co.	5 (182)	9 (49.8)	Nanya Plastics Corp.	40 (14)	49 (3.4)
Delta Electronics Inc.	6 (82)	11 (24.6)	Shin Jiuh Corp.	41 (14)	29 (7.6)
HannStar Display Corp.	7 (79)	48 (3.6)	Far Great Plastics Industrial Co.	42 (14)	33 (5.2)
Winbond Electronics Corp.	8 (77)	6 (103.8)	eMemory Technology	43 (13)	59 (1.6)
Siliconware Precision Industries Co.	9 (60)	13 (18.8)	Acer Inc.	44 (13)	38 (4.6)
BenQ Corp.	10 (58)	12 (20.2)	Chi Mei Optoelectronics Corp.	45 (13)	37 (4.8)
Via Technologies, Inc.	11 (52)	17 (16)	Wistron Corp.	46 (13)	-- (0)
Umax Data Systems Inc.	12 (48)	19 (14.6)	Taiwan Fu Hsing Industrial Co.	47 (13)	39 (4.4)
Silicon Integrated Systems Corp.	13 (41)	21 (12.6)	Grand HC Auto Tooling Corp.	48 (12)	-- (0)
AU Optronics Corporation	14 (40)	54 (2.4)	Powerchip Semiconductor Corp.	49 (11)	29 (7.6)
Mosel Vitelic, Incorporated	15 (40)	8 (63.2)	MiTac International Corp.	50 (11)	45 (3.8)
Promos Technologies, Inc.	16 (36)	18 (15.2)	Shin Tai Spurt Water of the Garden Tools Co.	51 (11)	39 (4.4)
Sunonwealth Electric Machine Industry Co.	17 (36)	24 (10)	All-Line Inc.	52 (11)	26 (9.4)
Silitek Corp.	18 (31)	25 (9.6)	Chao Ling Chemical Industry Co.	53 (11)	65 (0.6)
Hannspree, Inc.	19 (31)	67 (0)	ASUSTek Computer Inc.	54 (10)	34 (5)
National Science Council	20 (28)	7 (71.4)	Ritek Corp.	55 (10)	44 (4)
TYC Brother Industrial Co.	21 (28)	57 (1.8)	General Plastic Industrial Co.	56 (10)	53 (2.6)
Vanguard International Semiconductor Corp.	22 (27)	5 (107.2)	Lite-On It Corp.	57 (10)	59 (1.6)
Inventec Corp.	23 (26)	14 (18.6)	Global Sun Technology Inc.	58 (10)	-- (0)
Nanya Technology Corp.	24 (25)	22 (11.8)	Hiwin Technologies Corp.	59 (9)	63 (1.4)
Shin Yeh Enterprise Co.	25 (24)	55 (2)	Megic Corp.	60 (9)	55 (2)
Quanta Computer Inc.	26 (24)	59 (1.6)	Prokia Technology Co.	61 (9)	59 (1.6)
Primax Electronics	27 (23)	15 (17.6)	Nien Made Enterprise Co.	62 (8)	57 (1.8)
Globe Union Industrial Corp.	28 (21)	31 (5.8)	Chunghwa Picture Tubes	63 (8)	42 (4.2)
Advanced Semiconductor Engineering, Inc.	29 (20)	16 (17.4)	Inventec Appliances Corp.	64 (8)	51 (2.8)
Accton Technology Corp.	30 (19)	42 (4.2)	Lundar Electric Industrial Co.	65 (8)	45 (3.8)
Chung Shan Institute of Science and Technology	31 (18)	27 (9)	Yen Sun Technology Corp.	66 (7)	63 (1.4)
Mustek Systems, Inc.	32 (18)	10 (25.8)	Ritdisplay Corp.	67 (7)	66 (0.4)
Basso Industry Corp.	33 (17)	50 (3)	Uni-Splendor Corp.	68 (7)	51 (2.8)
Avision Inc.	34 (16)	34 (5)	AIPTEK International Inc.	69 (7)	39 (4.4)
Behavior Tech Computer Corp.	35 (16)	23 (10.4)	Auden Technology Corp.	70 (6)	34 (5)

Source: USPTO Patent Database and arranged by authors.

Semiconductor Industry

There were sixteen companies being categorized to semiconductor industry. One of them has no essential patent so this research analyzed the rest of 15 objects in this domain and results were shown in Table 2.

Analysis on patent performance by Taiwan Semiconductor Manufacturing obtained the highest ETS value (672.70). It is clearly that this company has the best performance on patent quality. Macronix International came in second with an ETS value of 167.57. The third place is United Microelectronics with an ETS value of 124.76. ETS value of top three companies were all greater than 120. According to Table 2, the 4th company on the ETS list, Siliconware Precision Industries, dropped to 76.59, ETS values of the 5th to 10th companies ranged from 30 to 40 and ETS values of the rest companies were all below 20. Based on the ETS values, three groups of companies with significant difference on performance could be distinguished.

Table 2. Semiconductor industry: patent indicators and rank.

Company	ETS Rank	ETS	TS Rank	TS	No. of Utility Patents*		CII	EPI**
Taiwan Semiconductor Manufacturing Co.	1	672.70	1(0)	542.50	434	(425)	1.25	1.24
Macronix International Co.	2	167.57	2(0)	180.18	182	(49.8)	0.99	0.93
United Microelectronic Corp.	3	124.76	3(0)	148.52	188	(395.8)	0.79	0.84
Siliconware Precision Industries Co.	4	76.59	4(0)	69.00	60	(18.8)	1.15	1.11
Vanguard International Semiconductor Corp.	5	43.55	6(+1)	34.29	27	(106.6)	1.27	1.27
Advanced Semiconductor Engineering, Inc.	6	35.63	8(+2)	26.20	20	(17)	1.31	1.36
Nanya Technology Corp.	7	33.28	9(+2)	26.00	26	(10)	1.00	1.28
Winbond Electronics Corp.	8	33.03	5(-3)	56.94	73	(103.2)	0.78	0.58
Silicon Integrated Systems Corp.	9	32.34	7(-2)	27.88	41	(12.4)	0.68	1.16
Powerchip Semiconductor Corp.	10	30.07	11(+1)	19.03	11	(7.6)	1.73	1.58
Via Technologies, Inc.	11	14.14	13(+2)	17.68	52	(16)	0.34	0.80
Mosel Vitelic, Inc.	12	13.78	9(-3)	26.00	40	(63.2)	0.65	0.53
Megic Corp.	13	10.15	14(+1)	8.46	9	(2)	0.94	1.20
Promos Technologies, Inc.	14	7.86	12(-2)	18.72	36	(15.2)	0.52	0.42
Faraday Technology Corp.	15	2.35	15(0)	5.60	14	(3.8)	0.40	0.42

* In bracket is the average of number of patents from 1998 to 2002.

** Calculate by patents from 1998 to 2002.

Source: USPTO Patent Database and arranged by authors.

The reason that Taiwan Semiconductor Manufacturing had the best performance on ETS is due to it had as many as 434 patents granted in years 2003 comparing to Macronix International's (182) and United Microelectronic's (188). On the other hand, Taiwan Semiconductor Manufacturing also had outstanding performance on EPI and CII in which both ranked top five in the semiconductor industry. That was why this company could be crowned as the top one on technology innovation competitiveness in the business.

In the TS and ETS ranking, there is no change of order for the top four and the bottom one but variations appeared in between. EPI values of Winbond Electronics and Mosel Vitelic were both much lower than the expected value 1, causing their ranking in ETS to drop as well. This means, the technological innovation competitiveness of these two companies were weaker than the overall technological force. By contrast, Advanced Semiconductor Engineering and Nan Ya Technology have much better EPI values and their ETS ranking were lifted showing their better competitiveness of innovation.

One particular case about the unique contribution of CII and EPI in technological output evaluation is the example of Powerchip Semiconductor. Powechip Semiconductor only held 11 patents in 2003, ranked 14 in the 15 companies compared, but its CII and EPI are both the highest in the semiconductor industry, making the TS ranking went up to 11th, and ETS ranking moved up to number 10. It is clearly that if number of patents were the only indicator to be compared, a company with outstanding competitiveness of innovation would be overlooked. Analysis of EPI could come in handy for detailed calculation.

Computer System Industry

In 2003, there were six companies being categorized to computer system industry. Two of them were excluded from the list since they did not own any essential patent. This research analyzed the rest of 4 objects in this domain and results were shown in Table 3.

Table 3. Computer system industry: patent indicators and rank.

Company	ETS Rank	ETS	TS Rank	TS	No. of Utility Patents*		CII	EPI**
Acer Inc.	1	35.01	1(0)	18.33	13	(4.6)	1.41	1.91
Compal Electronic, Inc.	2	5.96	3(+1)	9.94	14	(14.6)	0.71	0.60
Inventec Corp.	3	5.73	2(-1)	15.08	26	(17)	0.58	0.38
MiTac International Corp.	4	3.97	4(0)	6.30	9	(3.8)	0.70	0.63

* In bracket is the average of number of patents from 1998 to 2002.
** Calculate by patents from 1998 to 2002.
Source: USPTO Patent Database and arranged by authors.

Analysis on patent performance for computer system industry, Acer obtained the highest ETS value (35.01). As shown in Table 3, Acer is the only company that had an EPI value higher than expected value 1. This higher EPI value also produced a better ETS value compared to the other companies. For the rest of companies, Inventec and Compal Electronic had similar CII values. Invetec had better TS ranking since their number of patents is approximately two-fold of what Compal Electronic had. However, the EPI value of Compal Electronic is much higher than Inventec's and this produced a better ETS value for Compal Electronic. This case shows the weight of essential patent will emphasize the measuring of technological innovation competitiveness.

Computer Peripheral and Part Industry

There were twelve companies being categorized to computer peripheral and parts industry. One of them was excluded from the list since it did not own any essential patent in 2003. This research analyzed the rest of 11 objects in this domain and results were shown in Table 4.

Hon Hai Precision had the best ETS performance, as shown in Table 4, not only its number of utility patents but also the EPI value were both the best one in the industry. When comparing to the number two company on the list, Delta Electronics, Hon Hai Precision had a six times higher TS values and a eleven times higher ETS value. That was why this company could be crowned as the top one on technology innovation competitiveness in their business. This result raised the fact that ETS could put the accent on the innovation force better than using TS solely.

As for the rest of the list, Ritek and Avision had similar number of patents and CII values and Ritek ranked lower than Avision in TS ranking. However, Ritek had a much higher EPI value (1.2) comparing to what Avision had (0.16), resulting their significant difference on ETS values, which were 8.28 and 1.41, respectively. Another similar comparison is between Ritek and Umax Data Systems. Even though Umax Data Systems had five times higher number of patents than Ritek's, the significant difference on EPI values produced great difference on their ETS values making Umax Data Systems the worst one on the list. These cases provided good examples for the industrialists, researchers or national policy makers who wish to detect the real technological innovation capacity.

Table 4. Computer peripheral and part industry: patent indicators and rank.

Company	**ETS Rank**	**ETS**	**TS Rank**	**TS**	**No. of Utility Patents***		**CII**	**EPI****
Hon Hai Precision Ind. Co.	1	561.44	1(0)	460.20	390	(269.6)	1.18	1.22
Delta Electronics Inc.	2	50.41	2(0)	75.24	76	(24.6)	0.99	0.67
Shin Jiuh Corp.	3	17.95	5(+2)	15.47	13	(7.6)	1.19	1.16
BenQ Corp.	4	17.10	3(-1)	28.98	42	(29.6)	0.69	0.59
Silitek Corp.	5	11.89	4(-1)	20.50	25	(9.6)	0.82	0.58
Ritek Corp.	6	8.28	9(+3)	6.90	10	(4)	0.69	1.20
Behavior Tech Computer Corp.	7	5.45	7(0)	9.90	15	(10.2)	0.66	0.55
Mustek Systems, Inc.	8	2.97	10(+2)	5.94	18	(25.6)	0.33	0.50
ASUSTek Computer Inc.	9	2.94	11(+2)	4.60	10	(5)	0.46	0.64
Avision Inc.	10	1.41	8(-2)	8.80	16	(5)	0.55	0.16
Umax Data Systems Inc.	11	1.16	6(-5)	10.56	48	(14.4)	0.22	0.11

* In bracket is the average of patents from 1998 to 2002.
** Calculate by patents from 1998 to 2002.
Source: USPTO Patent Database and arranged by authors.

Discussion

In terms of R&D in technology industry, the innovation capacity is one of the most important objects. It plays a major role not only in competitive-cooperative relationship of companies but also in the strategic technology portfolios. Based on these, patent counts and citations could be measured as formal technological output.

A New Approach of Indicator: emphasis Of Technological Innovation

In this study, time-factor was added for forming the new indicators, EPI and EPS, as well as emphasizing on the different weight of citation patents. Since the cited number is influenced by the age factor, the earlier-published patent has higher cited probability. Therefore, each citation by specific assignee in different age seniority is unique and should not be treated under the same value if the innovation competitiveness has to be identified clearly. The ETS considers the number of patents, citations, as well as essential patent in the same time. The content of ETS is not only the technology strength but also the technological innovation force.

Availability Support Of ETS: Enforce The Impact Of Essential Patent

This research studies three high-tech industries in Taiwan by demonstrating the application of ETS values. As shown in Tables 2, 3 and 4, companies held better ETS ranking than TS ranking mostly mean they have better EPI ranking. By contrast, without the identification of essential patents and treating all citation patents the same will mix up the true value of citations. Given different weight of essential patents will enforce the impact of patent with innovation force.

Availability Support Of ETS: Aggrandize The Competitiveness Differences Between Companies

ETS combines the perspectives of number of patents, technology strength, and essential patent and raises the impact of innovation technology inside of patent. For example, the number of patents of Powerchip Semiconductor and Ritek are both low in the industries; even though the CII value of Ritek is in the middle level. If TS indicator were used solely, the great innovation competitiveness of Powechip and Ritek will not be awarded. On the other hand, some companies have similiar number of patents and CII values, such as Siliconware Precision Industries and Winbond Electronics in semiconductor and Behavior Tech Computer and Avision in computer peripheral and parts industry; indictors such as ETI and ETS can be used to aggrandize the technological innovation competitiveness differences between companies.

Association between Number of Patents and Patent Quality

This research does not have any conclusion on the positive association between number of granted patents and patent quality. Most cases may present this relation but Powechip Semiconductor in semiconductor industry and Riteck Corp. in Computer Peripheral and Part Industry raised two contrary examples. These two companies owned small number of patens but those patens produced outstanding EPI values and therefore providing these companies better ETS rankings. Future research could focus on understanding the association between quality and quantity of patent performance.

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