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An Exploratory Comparison Study of Inventor-authors with Their Non-patenting Peers in Research Productivity and Influence

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Abstract

The aim of this study is to explore the possible link between industrial technology development and scientific research, with specific focus on the development of industrial technology influences the inventor-authors' performance on scientific research. In this study, patenting activity was seen as representation of output of industrial technology; advised theses, funded research projects and journal articles were used as indicators of scientific research outcome. The author tried to examine the patents granted to and research output generated by members affiliated with Taiwanese Universities to reveal the productivity distribution and research performances of inventor-authors and non-patenting peers by taking bibliometrics approach. Patenting Activity Index and Academic Activity Index were used for presenting research output. Results showed that Inventor-authors performed above average both in technology development and research activities. However, it is worth a closer look at the impact of collaboration and research strategies for future researches.

Keywords: Research Productivity; Industrial Technology Development; Productivity Analysis; Patenting Activity Index; Academic Activity Index

1. Introduction and Related Researches

Results of early studies on scholarly-industrial linkage showed limited links between research outputs of scholarly research and development of industrial technology. The weak subject-correlation and citation network indicated two parallel tracks of these two sectors (Price, 1965). The needs of knowledge imported from multidiscipline altered the development. The boundary between two tracks became blurred. It is found that there is closer link between scholarly research and development of industrial technology (Narin & Noma, 1985; Narin, Hamilton, & Olivastro, 1995). Not only the results of scholarly researches become foundation of industrial technologies (Narin & Noma, 1985; Zucker, Darby, & Brewer, 1998; Lo, 2010a), the researchers from academic sector play important roles in development of industrial technology (Zucker & Darby, 1996; Murray, 2002), enhancement of industrial

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technologies also turns into the driving force for advancing scholarly researches (Glanzel & Meyer, 2003). Besides interplay of scholarly researches and industrial technologies, the rise of intellectual property right and needs of industrialized outcomes of scholarly researches, attract administrative and researches involving in patenting activities. Besides protecting the research individuals' intellectual property right, patenting also guarantees the possible profit gain for stakeholders (Looy, Callaert, & Debackere, 2006; Lo, 2010b).

With the encouragements brought by the Bayh-Dole Act in 1980 as well as other Bayh-Dole-like acts, and the demand to show the social impact of higher education, universities, key role in creating and disseminating knowledge, have been taking proactive role in pursuing patenting activity. A new issue has been raised, did this shift result better links between industry and science, universities continue devoting to both sides of innovation, or this shift cause the imbalance, even alter the effort in scientific research? Previous studies found two sides of this story. Even with the interplay support to scholarly research and industrial technology development, it also occurred that the competition for resources, not just research human resources but also financial support (Geuna & Nesta, 2006). On the other hand, studies also found the benefit with researches put in effort in two parties, theoretical foundation enriched the technology development and implementation in technology enhancement and supported the growth of scholarly research (Zucker & Darby, 1996; Looy, et al., 2006), there was no evidence showed the drawback influence of industrial technology development on scholarly research (Meyer, 2006). Empirical studies even found that the productive institutes in patenting activities also present outstanding performance in scholarly research (Azagra-Caro, Carayol, & Llerena, 2006).

Two Bayh-Dole-like acts announced in Taiwan, Fundamental Science and Technology Act in 1999 and Government Scientific and Technological Research and Development Results Ownership and Utilization Regulations in 2000, encouraged administrative of Taiwanese Universities devote resources into patenting activities and the numbers of patents granted reward the investment of resources (Lo, 2008a, 2008b, 2009, 2010b, 2012). Similar question is also raised, will the effort and resources shift bring drawback on scholarly researches? In this study, author named the university faculty who issued journal articles and was granted with patents as inventor-author, and the colleague who published journal articles but did not own any patents as non-patenting peer. The aim of this study is to show the research output of Taiwanese Universities in both industrial development, which is presented by patenting activity and scientific research shown by the academic works, by answering the following questions.

- How are the members affiliated with Taiwanese Universities patenting active?
- What is the distribution of scientific research output conducted by patenting active inventor-authors?
- Are patenting active inventor-authors more productive in academic works comparing to their non-patenting peers from the same research groups?

2. Method, Indicators and Data

2.1 Method

The author took bibliometrics approach to reveal research performance. Number of patents granted was used as indicator for performance of technology development, and number of journal articles published, number of advising theses/dissertations and number of funded research projects were seen as tokens for outcomes of scientific researches.

2.2 Scope and samples

The author identified and searched data for the universities that were listed in the directory of Universities/Colleges in Taiwan, provided by Ministry of Education, Taiwan, R.O.C. An authority name file was maintained to cover the issue of name changed. All the universities/colleges were included for study on patenting activity. Investigation on scientific research performance was only conducted for the sampled universities/colleges which were productive in patenting activities, from core zone by Bradford Distribution Principle, and with criteria of geographic nearby, comparable research disciplines and school attributes. The universities were ranked by the number of patents granted. The ones in core zone by Bradford Distribution were candidates for further study. For comparison purpose, purposive sampling technique was used. The ones with same geographic attribute, cover similar research disciplines in science area and with same governing system were identified. Productive inventors and peers from the same research institutes or departments were included for comparison study on productivity of inventor-authors and non-patenting peers.

Data analyzed in this study was searched and extracted from the following sources, (1) Patent: Taiwan Patent Search, Intellectual Property Office, Ministry of Economic Affairs, Taiwan, R.O.C.; (2) Journal articles: Science Citation Index Expanded and Social Science Citation Index via platform Web of Science; (3) Theses/Dissertations: National Digital Library of Theses and Dissertations in Taiwan; (4)

Research project: Database of Research Grant Proposal, Ministry of Science and Technology, Taiwan, R.O.C. Time coverage for data was from 2004 to 2010. All the data were searched, collected, streamlined, counted based on the criteria for listed indicators.

2.3 Indicators

Five indicators, three types of indexes, proposed by the author, were used in this study to show the research output for sampled universities and member affiliated.

2.3.1 Invention Index (InI), number of patents granted, fraction is used for co-owned patents

This index shows the productivity of inventor-authors in developing industrial technologies by taking number of patents granted into account.

Invention Index of inventor-author J $=\sum_{i=1}^{n}\left(\frac{1}{m1}+\frac{1}{m2}+\frac{1}{m3}+L+\frac{1}{mi}\right)$, n is number of patents granted to researcher J, m is number of inventors of patent i.

2.3.2 Academic Index (AI)

This index presents the performance of inventor-authors and their non-patenting peers in academic works. The index is composed by three parts, journal article value, advising activity value and research grant value. Journal article value shows the contribution of researchers to journal article publications of the institutions they are affiliated. Advising activity presented by the number of theses or dissertations done by advisees of researchers is taken as a token for the effort that the researchers put in. Research grant indicates the portion of the research funding granted to the researchers comparing to the institutional funding.

Academic index of inventor-author J = Journal Article value + Advising Activity value + Research Grant value.

Average Academic Index $=\sum_{k=1}^{n}$(AI1+AI2+AI3 ...+AIK) ÷ N , n is number of researchers

1. Journal Article value,

$$\frac{\text{Number of journal articles published by individual}}{\text{Gross number of journal articles published by members of affiliated institution}}$$

2. Advising Activity value,

$$\frac{\text{Number of theses (dissertations) advised by individual}}{\text{Gross number of theses (dissertations) advised by members of affiliated institution}}$$

3. Research Grant value,

$$\frac{\text{Number of funded research proposals to individual}}{\text{Gross number of funded research proposals members of affiliated institution}}$$

For position the performance, Academic index ratio, $\frac{\text{Academic Index}}{\text{Average Academic Index}}$ is used.

2.3.3 Impact Index (ImI), average times cited of journal articles published

This index shows the research impact of inventor-authors in scientific researches by average times cited of journal articles. Two types of ImI values are used, one is the value includes times of self-citation and the other one is the value excludes times of self-citation.

Impact Index of inventor-author J $= \left[\sum_{i=1}^{n} (TC1 + TC2 + TC3 \ldots + TCn) \right] \div n$, n is number of journal articles published by researcher J, TC is times cited of journal article i.

3. Preliminary Findings

3.1 Patenting activities, description of basic counts

There were 91 universities took part in patenting activities during the period of 2004 to 2010. Total 8,202 patents granted, including 3,586 invention patents, 4,476 utility model patents and 140 design patents. The followings were concluded from observations on preliminary study.

3.1.1 Taiwanese universities continue devoting to patenting activity, General Universities and Universities of Science and Technology focused on different patenting strategies

This study expanded the time range and included the patents granted back to year 2000. There were 8,710 TIPO patents identified. Put all the patent data together and looked into the numbers of patents granted annually. It was observed that Taiwanese universities continued devoting effort in patenting activity. Analyzing the distribution and growth of patents granted by issued year, with the average examining time for patenting process, and taking the results of tracing the origin of technologies, four time zones could be identified as initiating (2000-2002, estimated R&D period: 1998-2000), developing (2003-2005, estimated R&D period: 2001-2003), adjusting (2006-2008, estimated R&D period 2004-2006), and growing (2009-2010, estimated R&D period: 2007-2008).

Further examination on types of patents granted to General Universities and Universities Science and Technology, it was also observed that different patenting approaches were taken by the group of General Universities and the group of Universities of Science and Technology. Among the 108 universities taking parts in patenting activities, General Universities targeted applying invention patents and different from General Universities, Universities of Science and Technology had higher priority in applying utility model patents. Figure 1 shows the results of patent count by types of universities and patents, dark gray presenting invention patents, and light gray presenting utility model patents for general university, light gray presenting invention patents and dark gray presenting utility model patents for university of technology and science. The 4 zones divided by solid lines were based

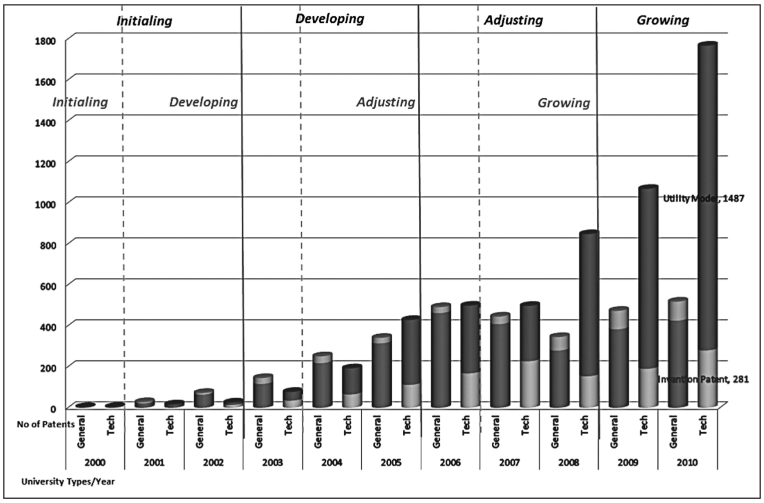

Figure 1. Patent Count, by Types of Universities and Patents

on the issued years and the 4 zones shown by dotted lines were drawn to present the estimated R&D periods.

3.1.2 Productivity pattern shifted of sampled universities, patenting strategies applied fitted in the general pattern

For further examination on productivity and research impact of inventor-authors, sampled universities were identified by productivity, research and geographic attributes. Figure 2 is a visual presentation of the numbers of invention and utility model patents granted to the sampled universities, and three growth curves, based on total numbers of patents, are also presented. The sampled universities have gone through funding changes due to the financial policy of Ministry of Education of Taiwan and the change became driving force behind the development. Among the sampled universities, one general university demonstrated linear curve, but shows two productive points during the examining period, the first one was in 2007 and the second one was in 2010. The other general university shifts the focus to other activities and puts in less resource in patenting activity (Note 1). The only university of technology and science included presented the logistic growth curve, with slow start and rapid growth in later years. The results of reviewing types of patents granted, which present the similar situation observed in previous studies (Lo, 2008a, 2008b, 2009, 2010b, 2012), the author suspects that General Universities and Universities of Technology and Science were still taking different strategies in invention and utility model patenting, general

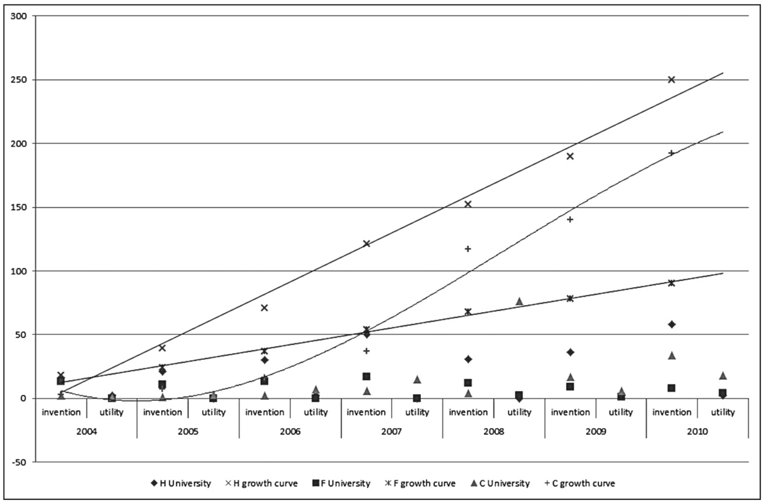

Figure 2. Patent Counts and Growth Curves of Sampled Universities

universities took more actions in invention patents and University of Technology and Science was more focused on utility model patents.

3.1.3 Intra-sector collaboration with extension of scientific research to patenting

From the result of authoring analysis, it was found that 80% of the patents were works done by the intra-sector collaboration; inventors of the research team were either from the same department or were from different departments but affiliated with same institutions. There was no indication showed that the collaboration was extended to inter-sectors, industry or governmental agency.

Tracing the source of the inventions by further examining the academic works done by inventor-authors, it was found that higher percentage of inventions were extensions of the academic works of inventor-authors or advisees of inventor-authors. This implied the strategy of transformation of scientific research to industrial technologies, spill-over from academic sector to industrial sector.

3.2 Research productivity and academic influence of inventor-authors and their peers

From the sampled universities, there were 574 inventors found, including faculty members, researchers and students from sampled institutes, 26 active patenting inventors were chosen as inventor-authors who had invention indexes that were greater than 2 and were granted more than 5 patents. Based on the chosen inventor-authors, there were 216 peers were identified from the departments they were affiliated. Information of journal articles, advising information and research grants related to the sampled inventor-authors and peers were retrieved accordingly. Table 1 lists the numbers of inventor-authors and peers from the sampled universities.

3.2.1 Research output of inventor-authors and peers, inventor-authors tend to have larger share

The author examined the research outcomes of the members from sampled groups of 3 universities, H, F, and C to show the research output accordingly. H University is a national, general university. Table 2 lists statistical results of the academic works done by inventor-authors and total sum with their peers from same research groups of H University. The 12 inventor-authors from H University were from 2 colleges and 5 departments. Those inventor-authors were granted 152 patents during years 2004 to 2010. In the same period, they also published 361 journal articles, advised 267 theses/dissertations and 114 research projects approved. Except group-S, with Research Population (RP) (Note 2) that was from 3.57% to 42.86%, inventor-authors contributed 5.13% to 83.42% of the academic works, the contribution was above the percentage of research population.

Table 3 shows the academic works done by inventor-authors and the sums with their peers from same groups of F University. The 9 inventor-authors from F University were from 4 colleges and 7 departments. The inventor-authors were granted 45 patents, with 154 published journal articles, advised 153 theses/dissertations and 62 research projects funded from year 2004 to year 2010. With the research population (RP) between 5% and 7%, inventor-authors Total Contributed (TC) (Note 3) over 10% of the academic works except for groups CH

Table 1. Inventor-authors and Peers from the Sampled Universities

	H University			F University			C University		
	Dept.	IA	Peer	Dept.	IA	Peer	Dept.	IA	Peer
Dept.	group-E	2	12	group-A	1	17	group-CH	1	17
	group-MA	5	16	group-CH	3	13	group-E	1	9
	group-ME	1	27	group-CO	1	15	group-ME	3	18
	group-P	3	4	group-E	1	18			
	group-S	1	4	group-F	1	14			
				group-L	1	14			
				group-M	1	18			
Total		12	63		9	109		5	44

Table 2. Academic Works of Inventor-authors and Peers from the H University

	No. of articles	No. of theses	No. of projects	Research population
group-E				
Total	180	234	80	14
Inventor-authors	39	54	14	2
%	21.67	23.08	17.50	14.29
group-MA				
Total	329	157	140	21
Inventor-authors	131	64	56	5
%	39.82	40.76	40.00	23.81
group-ME				
Total	170	487	118	28
Inventor-authors	35	25	7	1
%	20.59	5.13	5.93	3.57
group-P				
Total	187	177	54	7
Inventor-authors	156	122	37	3
%	83.42	68.93	68.52	42.86
group-S				
Total	4	8	5	5
Inventor-authors	0	2	0	1
%	0.00	25.00	0.00	20.00

(RP 18.75%, TC 22.22%), CO (RP 6.25%, TC 5.91%) and F (RP 6.67%, TC 8.25%). Inventor-authors from group CH contributed about the same percentage of academic works, and members from group CO showed the same level of contribution, but no similar performance level found in journal article publications. It is worth noting that the only inventor-author included in group L, had 9 journal articles published. It is more than 50% of the journal articles published during the examined period by the peer members from the same group, 16 journal articles in total by the affiliated members. The results show the centralization of research output, core members generate most research works.

Table 3. Academic Works of Inventor-authors and Peers from the F University

	No. of articles	No. of theses	No. of projects	Research population
group-A				
Total	131	204	73	18
Inventor-authors	37	21	7	1
%	28.24	10.29	9.59	5.56
group-CH				
Total	150	208	74	16
Inventor-authors	38	47	11	3
%	25.33	22.60	14.86	18.75
group-CO				
Total	49	143	45	16
Inventor-authors	0	11	3	1
%	0.00	7.69	6.67	6.25
group-E				
Total	168	235	67	19
Inventor-authors	33	24	11	1
%	19.64	10.21	16.42	5.26
group-F				
Total	86	37	71	15
Inventor-authors	4	2	10	1
%	4.65	5.41	14.08	6.67
group-L				
Total	16	200	33	15
Inventor-authors	9	24	7	1
%	56.25	12.00	21.21	6.67
group-MA				
Total	273	159	94	19
Inventor-authors	33	24	13	1
%	12.09	15.09	13.83	5.26

Table 4 provides the statistical results of academic research of inventor-authors and the sums with their peers from same groups of C University. The 5 inventor-authors from C University were from 2 colleges and 3 departments. Those inventor-authors were granted 64 patents, with 12 published journal articles, advised 24 theses/dissertations and 13 research projects funded during years 2004 to 2010. From the research outcomes, it appeared that the inventor-authors from C University showed different strategies in research activities comparing to inventor-authors from H and F Universities, focus on industrial technology developments rather than put two sides into consideration. The share of contribution to academic works was smaller with the similar share in research population.

3.2.2 Productive inventor-authors show greater performance in both industrial technology development and scientific research

Further comparison was made on academic performance among productive inventor-authors and peers from same disciplines. Number of advised theses/dissertations, number of research projects and journal article publications were taken as tokens for academic performance. The results show that productive inventor-authors were not only active in patenting activity, but also demonstrated higher productivity compared to non-patenting peers. Table 5 lists the invention

Table 4. Academic Works of Inventor-authors and Peers from the C University

	No. of articles	No. of theses	No. of projects	Research population
group-CH				
Total	71	69	32	18
Inventor-authors	7	3	7	1
%	9.86	4.35	21.88	5.56
group-E				
Total	9	26	27	10
Inventor-authors	1	4	3	1
%	11.11	15.38	11.11	10.00
group-ME				
Total	41	97	38	21
Inventor-authors	4	17	3	3
%	9.76	17.53	7.89	14.29

and academic indexes of productive inventor-authors of sampled fields, and figures 3 to 5 are visual presentations of the distribution.

Figures 3 to 5 show that inventor-authors gained greater Academic Index values comparing to average index value, position above Average Academic Index. The sampled inventor-authors are positioned by Inventor Index, calculated based on the number of patents, and Academic Index, computed according to the output of academic researches including number of journal articles published, number of theses/dissertations advised and number of projects granted. The titles, such as ee_2(2.00, 0.47) should be read as area_id(inventor_Index, academic index) and ee_AI, 0.17 should be read as area_average academic index, value.

For H University, inventor-authors presented greater productivities in academic works and industrial technology development; especially members of group-P, the sampled inventor-authors played leading roles in both sectors. (Figure 3) One exception was observed in group-S, inventor-author showed limited performance.

Table 5. Patenting Activity (Inventor Index) and Academic Strength (Academic Index Ratio) of Productive Inventor-authors from Sampled Universities-H, F, C

H University			F University			C University		
Area Inventor	Inventor Index	Academic Index Ratio[a]	Area Inventor	Inventor Index	Academic Index Ratio	Area Inventor	Inventor Index	Academic Index Ratio
p_1	13.63	2.49	l_1	3.70	4.47	ma_1	9.92	2.16
ma_1	11.65	2.53	f_1	3.00	1.21	me_1	8.95	1.01
p_2	10.15	1.53	ma_1	2.25	2.46	me_2	7.70	1.94
s_1	8.50	0.42	co_1	2.00	0.77	e_1	6.00	1.25
e_1	5.67	0.87	ch_1	1.75	0.71	me_3	2.70	0.00
ma_2	3.25	1.81	a_1	1.37	2.57			
me_1	2.83	2.85	e_1	1.25	2.93			
p_3	2.78	1.13	ch_2	1.00	1.11			
ma_3	2.50	1.60	ch_3	1.00	1.52			
ma_4	2.50	1.27						
ma_5	2.20	1.24						
e_2	2.00	1.58						

[a] Academic Index Ratio=Academic Index ÷ Average Academic Index, AIR

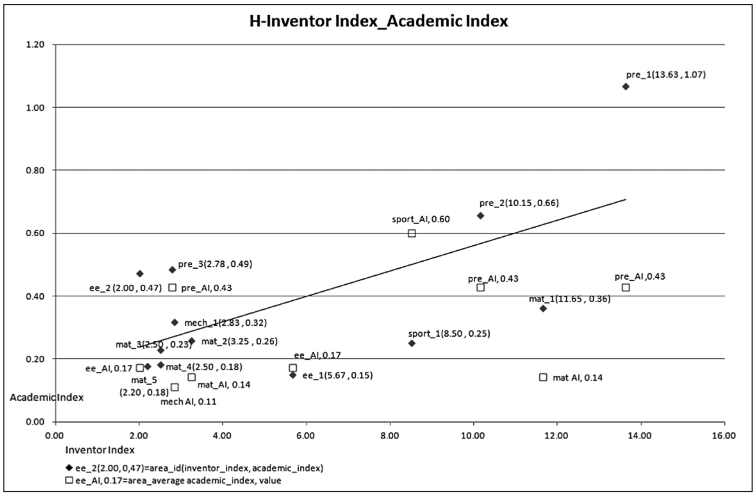

Figure 3. Performance Plot of Inventor-authors and Non-patenting Peers of H University

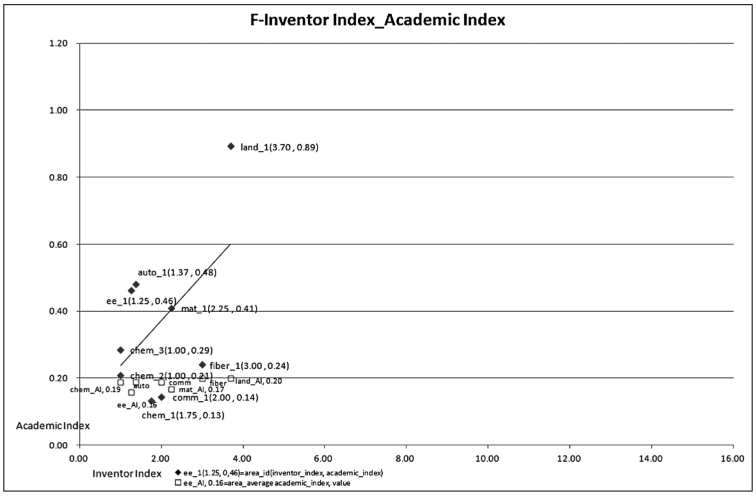

Figure 4. Performance Plot of Inventor-authors and Non-patenting Peers of F University

The results of plotting academic index and invention index showed that the inventor-authors from F University more focused on academic work. Most productive inventor-authors with higher performance in academic works had above average Academic Index value. Two exceptions were members from group-CO (comm_AI, comm_1) and group-CH (chem_AI, chem-1). Figure 4 is a visual presentation of plotting results.

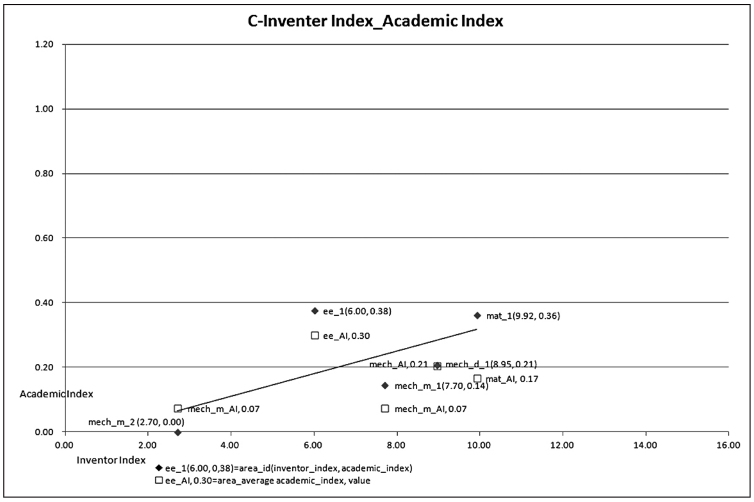

Figure 5. Performance Plot of Inventor-authors and Non-patenting Peers of C University

Research groups sampled from C University put in more effort in developing industrial technologies. There was no strong evidence to demonstrate the output from academic works done by these three groups. Inventor-authors from all three group-e, group-ma and group-me were more productive in both academic works and industrial technology development comparing to their peers, except me-2, whose academic index was below average of group me (Figure 5).

3.2.3 Higher impact of academic works of inventor-authors

To reveal the research impact of inventor-authors, other than demonstrating the influence of sampled inventor-authors in their academic works, the author further examined the cited level of works done by inventor-authors. Table 6 shows results from the analysis done for 3 members from sampled groups of sampled universities with the very top performance in research productivity.

The sampled member from H University did not just show outstanding performance in scientific research and technology development, but also present great impact on researches done by other scholars. Besides the patents granted to the researchers were cited 11.13 times in average, the cited level of journal articles was above the works done by members from the same group. The same scenario was also observed in the case of member from C University. From the case of Universities H and C, the productive inventor-authors demonstrate exceptional performance both in quantity and quality, taking a leader role in the

Table 6. Cited Level Analysis: Productive Inventor-author of Sampled Groups from Sampled Universities

	Times cited	Exclude self-citation[a]	ImI value with-self_ci	ImI value ex_self_ci
H Univ.				
p_1	1,388	1,317	15.25	14.47
group-P	2,111	1,981	11.41	10.71
F Univ.				
l_1	96	91	10.67	10.11
group-L	138	135	19.71	19.29
C Univ.				
ma_1	114	105	14.25	13.13
group-CH	420	396	8.24	7.76

[a] Self-citation is referring to the inventor-authors listed their own works as references. On the group level, it means the members cited works by themselves or by the members from the same group.

research group. It could also imply that they took research strategies that could be beneficial on both sides; however, the observation could not be verified in this study. The only variation was the member from F University. There is no evidence shows that the most productive inventor-author from F University has greater research impact comparing to the colleagues from the same group.

4. Reflection

There has been concern on the impact of devotion to patenting activity on performance of scientific research. In this study the author examined the indicators that present the output of patenting activity and scientific research. The statistical results show that (1) the patenting activities among Taiwanese University Community continue growing; (2) elite faculty members make major contribution to research and development achievement; and (3) there is no major impact of patenting activity on scientific research observed in this study. The productive inventor-authors maintain above average performance on both in productivity and research impact.

Among the sampled universities, faculty members of H and C Universities had above average outcomes in two sectors, scientific research as well as industrial technology development, and the members from F University demonstrated a possible minor different strategic approach. However, the observation on close and intra-sector collaboration and uniformity of researches done in two different types of research activities might imply hidden impact or drawback in further development. Detailed examinations on patent value and diversity of research facets are worth pursuing for future studies.

Notes

Note 1 Observation that was made from background study.

Note 2 Research Population (RP) $= \frac{\text{Number of inventor-authors}}{\text{Total number of Researchers}} \times \%$

Note 3 Total Contribution (TC) = $\frac{\text{Total number of academic works by inventor-authors}}{\text{Total number of academic works}} \times \%$

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發明作者與未參與專利活動學術同儕研究生產力與學術影響之比較研究

An Exploratory Comparison Study of Inventor-authors with Their Non-patenting Peers in Research Productivity and Influence

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摘　要

受到跨學科以及產業價值的影響，學術研究與產業技術發展之間的關連性越來越強。個人與團隊研究獲得之研發成果除被視為是學術研究產出，亦可被運用於產業技術研發與產品製作。學術研究成果與產業技術發展相互支援，以建構多元的研究發揮空間為目標。但積極投入產業技術發展，是否排擠學術研究所需要的研究能量與資源，進而對學術研究造成影響，阻礙學術研究量與質的發展？亦或是透過分享、整合資源與成果，良性推動學術研究與產業技術研發？本文以國內投入專利活動之學校教師為研究目標，藉由分析具有高專利活動力之教師與其所屬研究領域社群的研發生產力，了解發明作者與未參與專利活動學術同儕研究生產力與學術影響的分布狀況，以進一步探討產業技術發展是否對學術研究產生影響。本研究以專利產出作為代表產業技術研發成果的專利活動指標（Patenting Activity Index），指導學位論文數、研究計畫數以及期刊文章發表篇數為代表學術研究發展的學術活動指標（Academic Activity Index）。透過指標計算，比較發明作者與未參與專利活動學術同儕產出分布，了解產業發展與學術研究之間的關係。

關鍵字：研究生產力、產業技術研發、生產力分析、專利活動指標、學術活動指標

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