行政暨政策學報　第六十期
民國一〇四年六月　　第 137～173 頁
Public Administration & Policy, No.60
June 2015　　　　　pp.137～173

Reflections on the research commercialization policy: Have Taiwanese university scientists shifted their interest from basic to applied research?*

Wan-Ling Huang**

Abstract

This study investigates the extent to which university scientists have shifted their interest from basic scientific research to application-oriented research within the context of research commercialization policies. Data employed in this study come from a 2013 national survey of 474 university scientists and engineers in Taiwan, including both respondents who filed a Taiwan patent between June 2005 and June 2010 and those who have never filed a Taiwan patent. Our analysis indicates that university scientists' research tends to change to become more application-oriented, while the change in their research orientation is modest. It is also found that university scientists who received a Ph.D. degree prior to the adoption of research commercialization policies and those who have industry experience are likely to conduct research with a higher degree of application-orientation.

Key Words: Research commercialization policy, basic scientific research, applied scientific research, shifts in research interest, university patenting

---

* The data analyzed in this article were collected under the auspices of the two-year (2012-2014) research project titled "Project Selection by Academic Scientists under the Context of Academic Enterprise in Taiwan", funded by the Ministry of Science and Technology of Taiwan (Grant # 101-2410-H-032-015-MY2).

** Assistant Professor, Department of Public Administration, Tamkang University. Email: whuang24@mail.tku.edu.tw.

I. Introduction

Universities have traditionally contributed to society by creating, preserving and disseminating knowledge through research and education. Since the global economic structure has changed from labor-intensive industry to technology-driven industry, universities have been presented with a third mission-to play an active role in bridging knowledge creation and innovation via the transfer of technology and the engagement in research commercialization. The third mission of universities has been reinforced by the passage of the U.S. Bayh-Dole Act in 1980 allowing universities and non-profit organizations to patent publicly-funded research. The Act was drafted with the expectation that the privatization of intellectual property will provide incentives for both industry and universities to exploit university research and thereby facilitate innovation.

For the same reason, the Taiwanese government has adopted several laws and executive orders to encourage research commercialization in the last decades. Notable examples include the Science and Technology Basic Law (STBL) of 1999 that entitles universities to patent rights from research projects sponsored by government agencies. Subsidy Principles of Management and Promotion of Academic R&D Results of 2000 specifies that 40% of patent filing fees for all scientific research funded by the National Science Council (NSC)[1] will be paid by the sponsor, and 80% of patent filing and maintenance fees will be paid by the NSC if a patent title is awarded to the underlying invention. Government Scientific and Technological Research and Development Results Ownership and Utilization Regulations of 2003 further provides that universities and public research institutes are allowed to keep income from the

[1] The National Science Council has been merged with the Atomic Energy Council, becoming the Ministry of Science and Technology.

results of public R&D investments after distributing 20% of the income to government funding agencies.

Some studies have investigated the impact of the research commercialization policy in Taiwan and found increases in industry-university collaboration, increases in intellectual property infrastructure, and increases in patenting as well as licensing activity after the passage of the STBL (Chang, Chen, and Yang, 2006; Chang and Chen, 2011; Chang, Chen, Hua, and Yang, 2005, 2006). Although the prior research on the STBL takes a positive position regarding the impact of the research commercialization policy, some authors argue that because academic scientists have limited resources and time their engagement in activities related to research commercialization may decrease the effort and time available to publish (Jensen, Thursby, and Thursby, 2003). Likewise, some scholars adopt an “anti-common perspective” warning that formal intellectual property rights may increase the costs of using prior scientific knowledge and thus impede cumulative research productivity (Fabrizio and Di Minin, 2008; Heller and Eisenberg, 1998; Murray and Stern, 2007; Nelson, 2004). Even worse, some authors argue that encouraging academic scientists to pursue research commercialization may eventually shift their attention from basic scientific research to applied research that provides more technological and commercial opportunities (Fabrizio and Di Minin, 2008; Geuna and Nesta, 2006).

Prior studies have addressed the concern by examining the relationship between the publishing and patenting activities of academic scientists and have reported that inventors tend to publish more (Azoulay, Ding, and Stuart, 2009; Breschi, Lissoni, and Montobbio, 2008; Buenstorf, 2009; Van Looy, Callaert, and Debackere, 2006), implying that research commercialization may increase rather than decrease scientific productivity. However, the analysis of scientific and patent production tells us little about the extent to which research commercialization shifts university scientists’ interest from basic to applied science since applied research can be published as well (Agrawal and

Henderson, 2002; Murray and Stern, 2007). Some authors argue that university scientists' shifting their interest toward applied science is unlikely because decisions to engage in patenting activity typically occur during the research process, not in the selection of a research project (Agrawal and Henderson, 2002; Dai, Popp, and Bretschneider, 2005). However, few empirical studies have been conducted to test this argument.

Accordingly, this study aims to investigate the extent to which university scientists have shifted their interest from basic scientific research to application-oriented research, which aims to solve practical problems with little intention of improving the general understanding of scientific phenomena, 15 years after the adoption of the STBL. Data employed in this study come from a 2013 national survey of 474 university scientists and engineers in Taiwan, including both respondents who filed a Taiwan patent between June 2005 and June 2010 and those who have never filed a patent. Our findings indicate that university scientists' current research seems to be more application-oriented compared to the research they conducted as Ph.D. students. However, their current research orientation is generally located in the middle of the basic-to-applied science continuum, indicating that it is more likely that the university scientists are looking for a balance between the traditional university mission and the new university mission by doing research on topics that have basic scientific merit but also take practical application into consideration. This study also shows that the STBL tends to institutionalize in universities the norms of research commercialization. University scientists who were trained during the post-STBL period perceive a greater support for research commercialization in the university from which they earned their Ph.D. degrees. However, the research conducted by scientists who were trained during the pre-STBL period and so were more instilled with the norms of open science shows a greater tendency to move toward the applied side of research as a result of the influence of social norms in their work environment, their knowledge and experience of research and their attainment of job security.

In the next section, we first review studies relevant to the relationship between research commercialization and scientific progress and discuss the influence of academic training and industry experience governed by the research commercialization policy. Then the section introducing data, measures of studied variables and method follows. Finally, we present the analysis results and discuss the implications of our findings.

II. Literature review

Since the passage of the U.S. Bayh-Dole Act of 1980, governments around the world have adopted similar legislation that allows universities to hold intellectual property rights from research funded by government agencies (Abreu and Grinevich, 2012; Baldini, 2006; Moutinho, Fontes, and Godinho, 2007). In the 1999, the Taiwanese government also enacted the Science and Technology Basic Law, which legitimized the activity of patenting and selling publicly-funded research by universities. Such legislation presents universities with the responsibility of exploiting the results of scientific research with the expectation that the privatization of scientific knowledge will provide incentives for industry to further develop university inventions. Once intellectual property rights of publicly-funded research are transferred from the government to the universities, private firms will be able to appropriate the outcomes of their future investment in underlying technologies through licensing the university patents. Prior studies examining the impact of U.S. Bayh-Dole Act generally indicate that the Act effectively increases the utilization of university inventions (Mowery, Nelson, Sampat, and Ziedonis, 2001; Mowery, Sampat, and Ziedonis, 2002; Mowery and Ziedonis, 2002).

Studies examining the Taiwanese STBL also show positive effects from the research commercialization policy on facilitating technology transfer from universities to industry (Chang, Chen, and Yang, 2006; Chang and Chen, 2011; Chang, Chen, Hua, and Yang, 2005, 2006).

Despite its promise, there is a debate in the literature regarding whether research commercialization has a positive or negative impact on scientific progress (Kumar, 2010; Larsen, 2011). The research commercialization policy, explored further below, seems to successfully facilitate university patenting and licensing, but it remains unclear whether or not this success comes at the expense of long-term scientific development. The next section first presents the disputes about the relationship between research commercialization and scientific progress. Because the research commercialization policy may also influence the way university scientists were trained and their willingness to work in industry, it then discusses the possible impact of academic training and industry experience on the research orientation of university scientists.

1. Research commercialization and scientific progress

Prior studies indicate two possible ways in which research commercialization may threaten scientific progress. First, research commercialization may decrease university scientists' efforts and willingness to disseminate and share their scientific discoveries. Some studies examine whether patenting activity results in a decrease in scientific publication and found that scientists who produce more patented inventions tend to excel at publishing as well (Azoulay et al., 2009; Breschi et al., 2008; Buenstorf, 2009; Van Looy et al., 2006). This indicates that research commercialization may increase rather than crowd-out scientific production. However, other authors argue that the privatization of scientific research may motivate scientists to keep new discoveries secret (Jensen et al., 2003). Grushcow (2004) indicates that early data sharing by university scientists in scientific meetings decreased between 1980 and 1990, implying that the pursuit of intellectual property rights may lead university inventors to keep their inventions secret prior to patent filing. A 2000 survey of 2,893 life scientists at U.S. research universities reports that scientists who engage in commercial activity are more likely to withhold data as part of the publishing process compared to those who do not (Blumenthal et al., 2006). Chang and Yang (2008) surveyed 229 university patenters in Taiwan and found that engagement in research commercialization tends to result in more publication but that there is a significant lag between scientific publication and patent grant to enable exploitation and profitability of the patented inventions. Walsh and Huang (2014) examines the impact of commercial activity on publication secrecy and found that researchers who have filed a patent are more likely not to publish at all, or to publish incomplete data and to delay publication in both Japan and the U.S.

Traditionally, universities have institutionalized the norms of open science which includes the idea that scientific data and findings should be publicly available to avoid costs of duplicate research and to encourage the accumulation of scientific knowledge (Merton, 1942; Sampat, 2006). A patent system awards the patent holder the exclusive right to make, use, and sell the patented technologies and thereby probably leads to an increase in the cost of knowledge utilization. Accordingly, Heller and Eisenberg (1998) proposed an "anti-common hypothesis" arguing that the privatization of scientific research may make scientific discoveries less widely utilized because patent holders can block each other. Murray and Stern (2007) examines 340 peer-reviewed research articles published in the journal *Nature Biotechnology* over the period 1997–1999 and found that the same discovery may contribute to both basic scientific research and practical applications. However, the citation rate after the patent grant declines by 10 percent to 20 percent, providing moderate evidence for the anti-common hypothesis. Similarly, Fabrizio and Di Minin (2008) shows that patent holders tend to publish more than scientists who do not hold any patent, but the average number of citations to publications appears to decline in the case of scientists who patent more than once. These studies support the suspicion that research commercialization may impede the dissemination and accumulation of scientific knowledge.

The second potential threat of research commercialization to scientific progress is that research commercialization may shift university scientists' interest from basic to applied research. Some authors contend that academic capitalism may lead university scientists to be more interested in research that is likely to generate patentable inventions, particularly in fields that offer more technological and commercial opportunities (Fabrizio and Di Minin, 2008; Geuna and Nesta, 2006). It is probably that the degree to which research commercialization is detrimental to scientific progress depends upon the stages in which university scientists decide to engage in patent-related activity. Scientists who decide to pursue research commercialization during the stage of project selection are more likely to conduct research for practical application. In contrast, if decisions to pursue research commercialization are made after the selection or implementation of a project the nature of the research is likely to be driven by the scientists' interest in the race for better science.

The importance of basic science was early recognized by Bush's (1945) *Science: The Endless Frontier* that advocates government support for university research. While the economic benefits of basic scientific research are highly uncertain basic research very often produces results that have practical value in many research fields. If basic science is completely dependent on the investments made by industry, basic research is likely to be under-produced (Arrow, 1962; Nelson, 1959). Market failure to support basic research provides a rationale for government funding of university research since the production of basic research is socially desirable and government funding can ensure that university scientists have full freedom to choose research topics in which they are intrinsically interested. As indicted in Nelson (2004), it is important for academic scientists to select research projects based on their own curiosity because the advance of technology largely results through serendipitous discoveries found through the implementation of fundamental research. Research projects selected for economic payoffs alone may limit the serendipitous discoveries of basic research that can be further developed in various ways by multiple actors (Nelson, 2004). Like Nelson, Strandburg (2005) also calls for preserving curiosity-driven research whose economic payoffs are unpredictable but whose outcomes will probably result in long-term technological development. Accordingly, if academic scientists who are supposed to carry out fundamental research turn instead to application-oriented research that chiefly aims to solve practical problems for economic benefit alone, disadvantages to society may result.

Thursby and Thursby (2002) claims that increases in university patents and licenses are the result of the increased willingness of university scientists and administrators to engage in research commercialization rather than a shift in the focus of university research from basic to more applied work. Agrawal and Henderson (2002) and Dai et al. (2005) also argue that many university scientists tend to make decisions to patent when clear research findings are available and therefore they are unlikely to change research focus for the pursuit of intellectual property rights. However, few studies empirically test whether research commercialization is promoted at the expense of basic research although there are some exceptions. Carayol (2007) points out that scientists' interests in patenting do not lead them to conduct more applied work. His case study on the University Louis Pasteur reports that scientists who publish high quality articles, measured using impact factors of journals where the papers were published, are more likely to patent. Carayol's measurement is problematic because it mistakenly assumes that application-oriented research cannot be published in high quality journals. For instance, the *Journal of Applied Ecology* has an impact factor of 4.75 and ranks in the first quartile in the subject category of ecology. The journal's website indicates that "…the editors encourage contributions that use applied ecological problems to test and develop basic theory…[2],” indicating that the journal is interested in publishing research that has both scientific and practical merits.

Chang and Yang (2008) shows that university scientists who hold more patents and licenses do not engage in more practical academic research, which was measured using a survey question asking the respondents to indicate the extent to which their research conducted during 2000 and 2002 was application-oriented. This study overcomes the measurement problem of Carayol’s study but has other weaknesses. First, they identified a sample of university patenters by relying on a self-reported patent database managed by the Taiwanese NSC. Their sample may not be representative because many university scientists did not disclose their patent information to the database. Moreover, their study excludes non-patenters by assuming that non-patenters only engage in paper publication without recognizing the fact that many university scientists and engineers may intend to patent their inventions but eventually fail to do so.

Azoulay et al. (2009) investigates 3,862 academic life scientists employed at universities and non-profit research institutes between 1968 and 1999 and reports that the patenting experience is positively associated with the latent patentability of published research, the number of publications with industry coauthors, and the average commercial score of journals where the research was published. Their study is in line with the concern that the trend of research commercialization encourages university scientists to shift their research focus to topics of commercial interest. Since this study focuses on the field of life science, which has more commercial opportunities, it is not clear whether the interest shifts of university scientists are also common in other scientific fields. Due to the weaknesses of those prior studies, the proposed study investigates the extent to which academic scientists and engineers in Taiwan have become more interested in applied research during the post-

[2] *Journal of Applied Ecology*. From http://www.journalofappliedecology.org/view/0/aimsAndScope.html. Retrieved August 14, 2014.

STBL period by comparing the nature of the research projects they chose to conduct between 2010 and 2013 with their Ph.D. dissertations.

2. The impact of academic training and industry experience

Academic training governed by research commercialization policies may encourage university research to be more application-oriented. It is thus useful to compare the nature of research projects conducted by university scientists who received a Ph.D. degree prior to the passage of the STBL with those who graduated during the post-STBL period. Some authors contend that junior scientists have been trained in the paradigm of research commercialization so that they may feel more comfortable in engaging in research projects that are inspired by practical uses (Azoulay, Ding, and Stuart, 2007; Bercovitz and Feldman, 2007; Renault, 2006). In contrast, senior faculty who had been trained with the norms of open science may tend to believe that scientific knowledge should be publicly available and openly examined, and are thereby less likely to engage in research commercialization (Bercovitz and Feldman, 2008). Moreover, senior scientists have already committed themselves to a specific research trajectory, and the dependence on the chosen path may cause senior scientists to hesitate to shift their career goals toward entrepreneurialship (Ambos et al., 2008). Accordingly, it is reasonable to expect that the more years since university scientists have graduated from their Ph.D. programs, the less likely they will be to engage in application-oriented research.

On the other hand, the life cycle theory posits that the tenure system puts pressure on junior scientists to focus on research and publication activities, and research publication efforts tend to decline after receiving tenure (Levin and Stephan, 1991; Thursby, Thursby, and Gupta-Mukherjee, 2007). Accordingly, it can be argued that senior faculty members will be more likely to conduct application-oriented research because they have reached a certain level of job security and have more flexibility to consider alternative career paths (Buenstorf, 2009; Moutinho et al., 2007; Stephan, Gurmu, Sumell, and

Black, 2007). In addition, senior faculty members have already mastered the theory and research in a particular field and thereby are more capable of discovering possible applications of knowledge than are junior faculty members (Huang, Feeney, and Welch, 2011). Accordingly, it is also reasonable to expect that the number of years since graduation will be positively associated with the selection of application-oriented research projects.

Although being trained in the paradigm of research commercialization may increase scientists' interest in application-oriented research, the social norms in work environment may have greater influence on university scientists' project selection (Bercovitz and Feldman, 2008). Since the STBL was adopted more than 15 years ago, scientists who were trained with the norms of open science may have been institutionalized by the localized norms in their work environment that value research commercialization. Moreover, while it may be true that senior faculty members tend to be locked into a chosen research trajectory, it does not follow that they are thereby incapable of adjusting the research orientation within their own area of expertise. As indicated in Slaughter, Archerd and Campbell (2004), the boundary between basic and applied research may not be so strict and narrow that it cannot be crossed with few difficulties. The proposed study thus expects that scientists who received a Ph.D. degree prior to the STBL are more likely to conduct application-oriented research than those who graduated during the post-STBL period.

The impact of past training and localized social norms in work environment on university scientists' project selection may further interact with the scientists' industry experience. Prior research indicates that university scientists who have stronger connections with industry tend to have higher acceptance rates and better performance of research commercialization (Chang, Yang, and Chen, 2009; Colyvas et al., 2002; Göktepe, 2008; Siegel, Waldman, Atwater, and Link, 2004). Ismail et al. (2008) points out that university scientists with industry experience are able to identify potential licensees and have a better sense of technological and commercial opportunities. As Stuart and Sorenson (2005) indicates, personal connections to industry significantly contribute to entrepreneurial activity because social networks play a vital role in facilitating the identification of promising opportunities and the mobilization of resources to exploit the opportunities. Bercovitz and Feldman (2011) also show that social ties with industry scientists increase a university research team's understanding of market needs and bring unique information to the innovative process. As the discussion above indicates, this study expects that scientists with industry experience are more likely to engage in application-oriented research whether they were trained in the paradigm of research commercialization or not.

III. Data, measures and method

1. Data

Data employed in this study come from a 2013 national survey of university scientists and engineers in Taiwan, including both respondents who filed a Taiwan patent application and those who have never filed a patent. To construct a patent applicant sample, we first identified all patent applications filed by research universities[3] in Taiwan between June 2005 and June 2010 through the Taiwan Intellectual Property Office (IPO) public online database and then included 1,985 inventors who currently hold full-time professorships at universities into the sample. To develop a non-applicant sample, we

[3] Since the purpose of this study is to understand the extent to which research commercialization has lead academic scientists who are supposed to do basic scientific research conduct more research with greater technological potential, scientists working in institutes of technology, which are expected to train professionals for industry and usually build strong connections with industry to facilitate technology development, and their research projects are removed from this study.

randomly selected a half of the identified patent applicants (N=993) and then paired each one with a randomly selected non-applicant from the patent applicant's academic department. Only those who currently hold a full-time professorship at a university and have never filed a patent according to the Taiwan IPO database were defined as eligible non-applicants. In sum, the total sample size is 2,978 (1,985 patent applicants and 993 non-applicants).

The survey was first distributed to a pretest sample consisting of 100 patent applicants and 45 non-applicants. With 64 responses received, item analysis, reliability test and factor analysis were conducted. Questions with low variation or poor validity were removed. The final survey was implemented online using *Survey Monkey* from mid-November, 2013 to mid-January, 2014. A hard-copy of the survey invitation was mailed to 1,885 patent applicants and 948 non-applicants with five personalized email reminders and two phone call contacts. Each of the invitations was labeled individually with a unique id and a password and directed the individual to the survey website. Of the 486 completed surveys, 12 were removed because of insufficient information or ineligibility. The final sample size for the analysis was therefore 474 surveys. The overall response rate of the survey was about 17%.

One purpose of the survey was to investigate the nature of research projects selected by the sampled university scientists. The respondents were asked to name five research projects they were deeply involved with between 2010 and 2013, excluding the research projects they participated in as Ph.D. students or as post docs. Then the named projects were piped into subsequent questions to collect data on the funding sources, the research orientation and the potential commercial significance for each project. The respondents were also asked to provide inputs on their professional background, attitude toward research commercialization, relationship with industry, perception of university policy and technology transfer offices and research and patenting activity.

2. Measures

Four variables are constructed to capture the nature of the research projects recently conducted by university scientists: *Recent Research Orientation*, *Commercial Significance*, *Government Funding* and *Industry Funding*. The respondents were asked to name five research projects they were deeply involved with between 2010 and 2013, excluding the research projects they participated in as Ph.D. students or as post docs. Then the respondents were asked to rate each of the projects they named on a basic-to-applied science continuum, to indicate the level of potential commercial significance for each of the projects and to provide inputs on the percentage of government and industry funding by which each of the projects were sponsored. *Recent Research Orientation* is measured as the average rate of the named projects on the basic-to-applied science continuum (ten-point Likert scale, 1=pure basic science; 5=oriented basic science; 10=pure applied research). According to Stokes (1997), our survey defined pure basic science as research that is guided solely by expanding human understanding about the phenomena of a scientific field without any intent of putting such understanding to practical uses; pure applied research is directed solely to satisfy societal needs without seeking fundamental understanding of the phenomena; oriented basic science refers to research that is inspired by practical uses but also seeks basic understanding of the phenomena. Higher value indicates that the respondents have been more involved with research guided by applied goals. *Commercial Significance* is measured as the average rate of potential commercial significance of the named projects (ten-point Likert scale, 1=low; 10=high). Higher value indicates that the respondents expect a higher level of commercial significance from the named projects. *Government Funding* and *Industry Funding* are measured as the average percentage of government and industry funding by which the named projects were sponsored, respectively. Higher value indicates that a greater portion of the respondents' research funding comes from government (or industry).

Two variables are used to understand the extent to which the respondents have shifted their interest from basic science toward applied science: *Ph.D. Research Orientation* and *Change in Research Orientation*. *Ph.D. Research Orientation* is measured using a question asking the respondents to rate their Ph.D. dissertation on the basic-to-applied science continuum (ten-point Likert scale, 1=pure basic science; 5=oriented basic science; 10=pure applied research). Higher value indicates that the research the respondents conducted as Ph.D. students is application-oriented. *Change in Research Orientation* is measured using an index which is calculated as:

$$\frac{(\textit{Recent Research Orientation} - \textit{Ph.D. Research Orientation})}{(\textit{Recent Research Orientation} + \textit{Ph.D. Research Orientation})}$$

The possible scores of the index range from -0.82 to +0.82. As the index moves toward +0.82, it indicates that recent research is more application-oriented than the Ph.D. research. As the index moves toward -0.82, it indicates that recent research is more basic science-oriented than their Ph.D. research.

Two variables are included to capture the respondents' attitude toward research commercialization: *Open Science* and *Market Science*. *Open Science* is measured using five questions asking the respondents to indicate the level of their agreement with the following statements (six-point Likert scale, 1=strongly disagree and 6=strongly agree): (1) Universities are non-profit organizations and therefore research outcomes should not be sold in the market; (2) Scientific knowledge is public goods and should be freely available to the public; (3) Government-funded research should be public goods; (4) Research commercialization impedes the progressive accumulation of scientific knowledge; (5) University faculty members should not delay publishing in order to wait for patenting. Higher value indicates that the respondents hold the norms of open science. The Cronbach's alpha for *Open Science* is .778. *Market Science* is measured using three questions asking the respondents to indicate the level of their agreement with the following statements (revised from Glenna et al., 2011) (six-point Likert scale, 1=strongly disagree and 6=strongly agree): (1) Practicability is the most effective arbiter of the value of scientific research; (2) Commercialization is the most effective arbiter of the value of scientific research; (3) University scientists should focus on production for market potential. Higher value indicates that the respondents recognize the responsibilities of academic scientists in developing and transferring knowledge. The Cronbach's alpha for *Market Science* is .878.

Ph.D. Culture is employed to capture the extent to which the institutions where the respondents received their Ph.D. training value research commercialization. This variable is measured as the average responses to four questions (six-point Likert scale, 1=strongly disagree and 6=strongly agree): (1) The university from which you earned your Ph.D. encourages faculty members to engage in patent-related activity; (2) Your Ph.D. dissertation advisor is actively involved with university-industry collaboration; (3) Your Ph.D. dissertation advisor frequently interacts with industry; (4) Your Ph.D. dissertation advisor actively engages in patent-related activity. Higher value indicates that the respondents were trained in an environment which is open to research commercialization. The Cronbach's alpha for *Ph.D. Culture* is .896.

Two variables are constructed to capture the extent to which localized social norms are along the lines of the national research commercialization policy: *Faculty Promotion* and *Departmental Norm*. *Faculty Promotion* is measured using a question asking the respondents to indicate the level of their agreement with the following description: Your university has adopted a policy to give credits in promotion decisions for faculty work that leads to patents and other intellectual property applied in technology transfer (six-point Likert scale, 1=strongly disagree and 6=strongly agree)[4]. *Departmental Norm* is measured by averaging responses to three questions (six-point Likert scale, 1=strongly disagree and 6=strongly agree)[5]: (1) Your department takes

4 The responses indicating "unknown" for this question are coded using a missing value.
5 Ibid footnote 4.

patenting into consideration in recruitment decisions; (2) Candidates' personal relationship with industry is relevant to recruitment decisions in your department; (3) Faculty in your department consider patenting as an important indicator of scholarship. The Cronbach's alpha for *Departmental Norm* is .868.

Post-STBL Graduates is used to indicate whether the respondents earned a Ph.D. degree during the post STBL period. Given that the STBL was adopted in 1999, the respondents who earned a Ph.D. in or after 2000 are considered as the post-STBL graduates and are coded one. Pre-STBL graduates are coded zero. *Industry Experience* is employed to capture whether the respondents have built a connection with industry. This variable is operationalized using a question asking the respondents whether they have ever been affiliated with a private company either as an employee, a consultant or an owner. It was coded one if yes and zero otherwise.

Table 1 presents the descriptive statistics of the sample included in the analysis. Among 474 respondents, about 74% filed a university patent between June 2005 and June 2010, and the percentage increases to around 81% for the pre-STBL graduates. The ratio of the respondents who earned a doctoral degree during the post-STBL period to those who received their degree prior to the adoption of STBL is nearly equal, while the percentage of post-STBL graduates is higher for the non-applicant group (about 63.2%). Almost a half of the respondents are full professors, 31.2% are associate professors, and 21.5% are assistant professors. On average, 36.7% of the respondents have affiliated with industry at some time, while the percentage decreases by about 10% in the non-applicant group. The respondents vary widely in their fields of science. Approximately, 6.1% of the respondents are from agricultural sciences, 4.6% from chemistry, 45.4% from engineering, 15.2% from life science, 8.6% from medical science, 4% from physics, 10.5% from computer science and 5.5% from other diverse group of fields. Almost all respondents have a Ph.D. degree (only 1.3% without the Ph.D.), and 44.3% of the respondents with a Ph.D. degree have been post-docs. Last, 84.6% of the respondents are male, and the percentage of males in the patent-applicant group is about 14% higher than the non-applicant group.

Table 1 Sample Description

	All Respondents	Applicants	Non-applicants	Post-STBL Graduates	Pre-STBL Graduates
Variables/Observation	**N=474**	**N=349**	**N=125**	**N=229**	**N=215**
Patent Application					
Yes	73.6	100.0	0.0	68.6	80.5
No	26.4	0.0	100.0	31.4	19.5
Graduation Years					
less than 16 years (post-STBL)	51.6	47.6	63.2	100.0	0.0
more than 15 years (pre-STBL)	48.4	52.4	36.8	0.0	100.0
Rank					
Assistant Professor	21.5	16.3	36.0	39.3	5.1
Associate Professor	31.2	32.7	27.2	41.0	21.4
Full Professor	47.3	51.0	36.8	19.7	73.5
Industry Experience					
Yes	36.7	40.7	26.1	33.0	41.1
No	63.3	59.3	73.9	67.0	58.9
Fields of Science					
Agricultural Science	6.1	5.7	7.2	4.4	8.4
Chemistry	4.6	4.0	6.4	4.4	5.1
Engineering	45.4	50.4	31.2	46.7	46.0
Life Science	15.2	12.6	22.4	15.3	14.0
Medical Science	8.6	8.9	8.0	7.9	7.4
Physics	4.0	3.7	4.8	4.8	3.7
Computer Science	10.5	10.0	12.0	11.4	10.2
Others	5.5	4.6	8.0	5.2	5.1
Ph.D. Degree					
Yes	98.7	98.9	98.4	100.0	100.0
No	1.3	1.1	1.6	0.0	0.0
Post-doc Experience					
Yes	44.3	42.6	49.2	51.1	38.6
No	55.7	57.4	50.8	48.9	61.4
Gender					
Male	84.6	88.2	74.6	82.4	87.0
Female	15.4	11.8	25.4	17.6	13.0

Note: Since 30 respondents did not report the year in which they received a doctoral degree, only 444 respondents can be included in one of the two classes of those receiving a Ph.D. prior to or after the adoption of the STBL.

Source: Completed by the author.

3. Method

This study examines the extent to which the research orientation of university scientists has shifted toward the applied side 15 years after the adoption of STBL based on mean comparison analyses. A paired-samples *t*-test was employed to examine whether the research orientation of the respondents' current projects is significantly different from the research orientation of their Ph.D. dissertations. Likewise, an independent-samples *t*-test was used to examine whether patent applicants and non-applicants (pre-STBL graduates and post-STBL graduates) differ from each other in terms of their research orientation, their attitude toward research commercialization and their perceptions of their Ph.D. institutions and current work environment. Scheffé post hoc tests in one-way analysis of variance (ANOVA) further allows us to investigate the mean difference among the respondents paired based on graduation years and industry experience.

Given that our samples include both university scientists who have filed a patent and those who have never filed a patent, we also employ propensity score matching (PSM) to match the respondents' propensity to file a patent on the basis of relevant demographic characteristics, including rank, industry experience, fields of science, post-doc experience and gender[6]. After controlling the factors that may influence the likelihood of filing a patent, we can reduce the potential influence of self-selection bias on the relationship between having experience of filing a patent and the variables of interest.

IV. Results

Table 2 presents the means of the studied variables for all respondents and the result of mean comparison between the patent applicants and non-applicants. Among all respondents, the average level of their Ph.D. dissertation

6 We did not use a propensity score matching the post-STBL graduates and pre-STBL graduates because graduate students have little freedom to determine for themselves when they graduate. The year in which university scientists received their Ph.D. degree is mostly determines by their ages.

on the basic-to-applied science continuum is 5.07 (*Ph.D. Research Orientation*). The average rate increases to 5.70 for the research they were highly involved between 2010 and 2013 (*Recent Research Orientation*). A paired samples *t*-test further shows that the difference between the two means is significant ($p<0.001$), indicating that university scientists have to some extent shifted their interest toward the applied side. Our analysis reports that both Ph.D. research and recent projects conducted by the patent applicants are more application-oriented than those implemented by their counterparts ($p<0.05$ and <0.001, respectively). *Change in Research Orientation* further indicates that the degree of shifting research orientation toward the applied side is greater for the patent applicants by 0.04 unit ($p<0.1$) compared to the non-applicants. Overall, the perceived level of potential commercial significance of the recent research is a bit high (rate=6.37), and the perceived commercial significance by the patent applicants is much higher than the non-applicants ($p<0.001$). Last, a majority of recent research is funded by the government, and the percentage of funding from industry is significantly higher for the patent applicants than their counterparts by 4.61% ($p<0.05$).

Table 2 Mean Comparison between the Patent Applicant and Non-Applicant Group

	All Respondents	Applicants	Non-applicants	T test	
Variables/Observation	**N=474**	**N=349**	**N=125**	**t value**	**Sig.**
Nature of Research Projects					
Ph.D. Research Orientation	5.07	5.18	4.77	2.00	*
Recent Research Orientation	5.70	5.99	4.87	5.35	***
Change in Research Orientation	0.06	0.07	0.03	1.70	†
Commercial Significance	6.37	6.88	4.91	7.20	***
Government Funding	80.79	80.59	81.37	-0.24	
Industry Funding	10.36	11.55	6.94	2.14	*
Attitude toward Research Commercialization					
Open Science	3.31	3.07	3.94	-7.75	***
Market Science	3.31	3.43	3.01	2.85	**
Ph.D. Culture	4.03	4.21	3.51	4.57	***
Localized Social Norms					
Faculty Promotion	4.21	4.12	4.47	-2.50	*
Departmental Norm	3.29	3.28	3.30	-0.14	

† $p<0.1$; * $p<0.05$; ** $p< 0.01$; *** $p< 0.001$

Source: Completed by the author.

After the passage of the STBL15 years ago, our analysis shows that university scientists on average do not hold strong norms of open science (mean=3.31), while such attitudes vary significantly across the patent applicants and non-applicants. In general, the non-applicants have a higher agreement on the idea that scientific knowledge should be publicly available, particularly when it is funded by government ($p<0.001$). On the other hand, patent applicants are more aware of the importance of putting scientific knowledge to practical uses ($p<0.01$).

Prior studies have indicated that past training and localized social norms in work environment tend to shape individuals' belief and cognition (Bercovitz and Feldman, 2007, 2008). It seems that patent applicants tend to be trained in environments that support research commercialization. The mean of *Ph.D. Culture* for the patent applicants is 0.7 higher than the non-patent applicants ($p<0.001$), indicating that the patent applicants are on average more likely to perceive that the university where they earned a Ph.D. degree actively encourages patent-related activity. In contrast to our expectation, however, non-applicants rated a higher agreement for the adoption of promotion systems that count credits of research commercialization by their universities (*Faculty Promotion*) ($p<0.05$).

Although we strategically sampled both university scientists who have filed a patent and those who have never filed a patent in order to make a comparison, it remains unclear whether or not the two groups are similar in baseline characteristics. To ensure that the patent applicant and non-patent applicant groups are comparable, we employ propensity score matching to account for the systematic difference in rank, industry experience, fields of science, post-doc experience and gender between the two groups. Table 3 presents the OLS regression estimation for the effect of having experience of filing a patent on the variables of interest. The first column displays the predicted effect of having experience of filing a patent when the difference in propensity to file a patent is not controlled. The second column shows differences between patent applicants and non-patent applicants when the propensity to file a patent is matched on the basis of relevant demographical characteristics.

Table 3 The Estimated Effect of Having Experience of Filing a Patent

	OLS regression (no covariates)		OLS regression (with covariates)	
Nature of Research Projects				
Ph.D. Research Orientation	0.42	*	0.15	
Recent Research Orientation	1.11	***	0.53	*
Change in Research Orientation	0.05	†	0.04	
Commercial Significance	1.96	***	1.01	**
Government Funding	-0.79		3.35	
Industry Funding	4.61	*	3.58	
Attitude toward Research Commercialization				
Open Science	-0.87	***	-1.00	***
Market Science	0.42	**	0.09	
Ph.D. Culture	0.70	***	0.58	**
Localized Social Norms				
Faculty Promotion	-0.35	*	-0.24	
Departmental Norm	-0.02		-0.36	*

Note: OLS = ordinary least squares

† $p<0.1$; * $p<0.05$; ** $p< 0.01$; *** $p< 0.001$

Source: Completed by the author.

The analysis results show that there might be selection bias among the respondents. After matching the propensity to file a patent, there is no significant difference between patent applicants and non-patent applicants regarding the research orientation of their Ph.D. dissertation, the level of change in their research orientation, the percentage of industry funds they received, their market science attitude and the faculty promotion system in their universities. On the other hand, patent applicants tend to perceive that their departmental norm is less supportive of research commercialization compared to non-patent applicants once the propensity to file a patent was matched.

The previous discussion implies that having experience of filing a patent may be positively correlated with the current selection of application-orientation projects, while it does not necessarily lead to a shift in research orientation from basic to applied science. Considering Table 2 and Table 3 together, the fact that university scientists have to some extent shifted their interest toward the applied side seems to be common and not limited to the scientists who have ever filed a patent. Moreover, patent applicants tend to be trained in an academic environment that is more open to research commercialization and thus are less likely to adopt open science norms than non-patent applicants. These results inform us concerning the importance of past training to research commercialization.

To further understand the impact of research commercialization policies on project selection by university scientists through academic training, we divided the respondents into two groups: Post-STBL graduates and pre-STBL graduates. Table 4 presents the result of mean comparison between the two groups. It seems that doctoral dissertations done by university scientists who earned a Ph.D. degree during the post-STBL period are more application-oriented than the work conducted by the pre-STBL graduates, however the difference is not statistically significant. In contrast, the average level of recent research on the basic-to-applied science continuum (*Recent Research Orientation*) is significantly higher for the pre-STBL group than for their counterparts ($p<0.01$), indicating that senior scientists tend to have more interest in application-oriented research than scientists in the early or middle stages of their careers. The index of change in research orientation (*Change in Research Orientation*) further shows that the degree of shifting research orientation toward the applied side is greater for the pre-STBL graduates by 0.07 unit compared to the post-STBL graduates ($p<0.01$). Similarly, pre-STBL graduates also perceive a higher level of potential commercial significance in their recent research than the post-STBL graduates do ($p<0.01$). Last, the percentage of research funding from government is fairly equal in the two groups, while the percentage of industry funding is much higher for the pre-STBL graduates ($p<0.05$). This is probably because senior scientists are more capable of building relationships with industry.

Table 4 Mean Comparison between the Post-STBL and Pre-STBL Group

Variables/Observation	Post-STBL Graduates N=229	Pre-STBL Graduates N=215	T test t value	Sig.
Nature of Research Projects				
Ph.D. Research Orientation	5.17	4.98	1.06	
Recent Research Orientation	5.44	5.94	-2.70	**
Change in Research Orientation	0.03	0.10	-3.39	**
Commercial Significance	6.05	6.83	-3.34	**
Government Funding	81.89	80.08	0.66	
Industry Funding	7.77	12.40	-2.35	*
Attitude toward Research Commercialization				
Open Science	3.38	3.23	1.34	
Market Science	3.21	3.35	-1.06	
Ph.D. Culture	4.17	3.91	1.90	†
Localized Social Norms				
Faculty Promotion	4.29	4.07	1.61	
Departmental Norm	3.27	3.26	0.09	

† p<0.1; * p<0.05; ** p< 0.01; *** p< 0.001

Source: Completed by the author.

Among other variables, the post-STBL and pre-STBL graduates do not have much difference in their attitude toward research commercialization. However, as we expected, scientists who were trained during the post-STBL period tend to perceive that research commercialization was valued and supported by the university where they earned their Ph.D. degrees ($p<0.1$). On the other hand, it seems that the post-STBL and pre-STBL graduates have similar perceptions of localized social norms in their work environment. This result may reflect the fact that many universities have adopted some strategies or policies to facilitate research commercialization in corresponding to the STBL.

We take a step further to investigate the impact of the interplay between past training and industry experience on project selection and attitude toward research commercialization. We compare the means of studied variables across the following four groups: Pre-STBL graduates with industry experience, pre-STBL graduates without industry experience, post-STBL graduates with industry experience and post-STBL graduates without industry experience. Table 5 presents the result of analysis of variance (ANOVA).

Table 5 The Result of Analysis of Variance (ANOVA)

Variables (Group I/Group J)	Pre-STBL without Industry experience	Post-STBL with Industry experience	Post-STBL without Industry experience
Ph.D. Research Orientation			
Pre-STBL with industry experience	0.51	0.05	0.14
Pre-STBL without industry experience		-0.46	-0.37
Post-STBL with industry experience			0.09
Recent Research Orientation			
Pre-STBL with industry experience	0.52	0.25	1.05 **
Pre-STBL without industry experience		-0.27	0.53
Post-STBL with industry experience			0.81 *
Change in Research Orientation			
Pre-STBL with industry experience	-0.02	0.01	0.09 *
Pre-STBL without industry experience		0.03	0.11 **
Post-STBL with industry experience			0.08
Commercial Significance			
Pre-STBL with industry experience	0.51	0.41	1.43 ***
Pre-STBL without industry experience		-0.10	0.92 *
Post-STBL with industry experience			1.02 *
Government Funding			
Pre-STBL with industry experience	-5.44	-0.08	-6.96
Pre-STBL without industry experience		5.36	-1.53
Post-STBL with industry experience			-6.89
Industry Funding			
Pre-STBL with industry experience	7.18	5.86	9.96 **
Pre-STBL without industry experience		-1.32	2.78
Post-STBL with industry experience			4.10
Open Science			
Pre-STBL with industry experience	-0.21	0.01	-0.38 †
Pre-STBL without industry experience		0.22	-0.17
Post-STBL with industry experience			-0.39
Market Science			
Pre-STBL with industry experience	0.44	0.15	0.54 †
Pre-STBL without industry experience		-0.29	0.10
Post-STBL with industry experience			0.39
Ph.D. Culture			
Pre-STBL with industry experience	0.17	-0.48	-0.05
Pre-STBL without industry experience		-0.65 *	-0.22
Post-STBL with industry experience			0.43
Faculty Promotion			
Pre-STBL with industry experience	0.02	-0.24	-0.16
Pre-STBL without industry experience		-0.26	-0.19
Post-STBL with industry experience			0.07
Departmental Norm			
Pre-STBL with industry experience	-0.13	-0.25	0.00
Pre-STBL without industry experience		-0.12	0.13
Post-STBL with industry experience			0.25

Note: The number in a cell is calculated by subtracting the mean of Group J from the mean of Group I.

† p<0.1; * p<0.05; ** p< 0.01; *** p< 0.001

Source: Completed by the author.

It seems that seniority is positively associated with the degree of changing research orientation to be more application-oriented. When not having had an affiliation with industry, pre-STBL graduates tend to have greater changes in research orientation ($p<0.01$) and perceive a higher level of potential commercial significance in recent research ($p<0.05$) than the post-STBL graduates do. Industry experience is also positively related to selection of research projects that are more application-oriented. Among the post-STBL graduates, scientists who have been affiliated with industry at some time tend to report a higher rate on the basic-to-applied science continuum ($p<0.05$) and perceive a higher level of commercial significance in their recent research ($p<0.05$) compared to those without industry experience.

Moreover, the pre-STBL graduates without industry experience tend to report a lower level of acceptance of research commercialization by the university where they received their Ph.D. degrees compared to the post-STBL graduates who have been affiliated with industry. This finding suggests that the value of research commercialization is more recognized by universities during the post-STBL period.

Compared to the post-STBL graduates without industry experience, the pre-STBL graduates with industry experience tend to conduct research with the consideration of practical uses in view ($p<0.01$), change their research orientation to a greater degree ($p<0.05$), perceive a higher level of commercial significance in their recent research ($p<0.001$) and hold a higher percentage of their research funding from industry ($p<0.01$). Although university scientists who graduated prior to the adoption of the STBL were in general trained with the norms of open science, industry experience leads them to adhere less to the norms of open science and to be more positive about market science compared to those who graduated during the post-STBL period but did not have industry experience ($p<0.1$).

V. Discussion and Conclusion

This study investigates the extent to which university scientists have shifted their interest toward research that is more application-oriented in the context of the national research commercialization policy. We compare the average level of Ph.D. dissertations on the basic-to-applied science continuum with the rate of recent research projects conducted by university scientists and observe a change in research orientation toward the applied side on the continuum. After controlling for the propensity to file a patent, it seems that non-patent applicants have a similar tendency to have their research orientation change as patent applicants.

Although our analysis shows a pattern of changes in research orientation by university scientists, we should be cautious about concluding that the national commercialization policy (STBL) has moved university scientists far away from basic science. Among all respondents, the average rate of recent research projects on the basic-to-applied science continuum is between 5 and 6, implying that university scientists may be more inclined to choose a project that has basic scientific merits but also takes practical uses into consideration. Our findings imply that the national research commercialization policy may motivate university scientists to engage in research that has both scientific merit and practical benefit, but does not lead university scientists to move too far away from basic science.

In line with Bercovitz and Feldman (2008), our analysis further shows that localized social norms in the work environment might have more significant impact than past training on scientists' project selection. Although university scientists who earned a Ph.D. degree during the post-STBL period were trained in an environment that values research commercialization, the pre-STBL graduates are more likely to conduct application-oriented research projects. One possible explanation is that the norms of market science that have been widely held in modern universities may blur the norms of open science that were inculcated into the pre-STBL graduates during their Ph.D. training and make them more likely to take practical applications into consideration when proposing a research project. As shown in Table 4, perceived localized social norms do not vary significantly between the pre-STBL and post-STBL graduates, indicating that universities in Taiwan have commonly been aware of the importance and value of research commercialization. This study also provides some evidence for the life cycle theory. Achievement of job security may provide university scientists with more flexibility to engage in application-oriented research since they are without the fear of not being able to publish enough for promotion. In addition, it seems that knowledge and experience in research can outweigh the dependence of senior faculty members on their established research areas. Our analysis provides some insights concerning the debate on the relationship between seniority and research commercialization involvement.

Several aspects of this study need to be pointed out. First, it captures the research orientation of the projects conducted by university scientists using self-reported survey data. This self-evaluation could be biased, especially when the underlying projects have produced patents or commercializable outputs. Secondly, it is almost impossible to completely rule out other alternative variables that may influence project selection by university scientists that make it difficult to assess individual impact of the STBL. Therefore, this study confines itself to providing a description of what has been observed 15 years after the adoption of the STBL and does not intend to make any causal claim. Third, the response rate of the survey was only about 17%. This is probably because online surveys usually result in a lower response rate compared to paper surveys (Nulty, 2008). The results of this study should be interpreted with caution because a low response rate may bias the findings.

Despite these limitations, this study has some implications for science and technology policy makers and university managers. This study adopts the position that research commercialization is the right way to go only when it does not sacrifice the progress of basic science. Our analysis shows that the current research commercialization policy seems to be appropriate in the sense that it does not shift university scientists' research far away from the basic science. Instead, it encourages university scientists to consider practical uses of their research to society but at the same time it supports their interest in adding to fundamental scientific knowledge. This is probably because the conventional promotion system adopted by most universities still awards more credits to publication than to research commercialization, which makes it important for university scientists to conduct research that has both scientific merit and practical value. However, some universities in the past couple of years have implemented a new promotion system that allows university faculty members to attain promotion based on their contribution to research commercialization. This new initiative may provide more incentives for university scientists to prioritize application-orientation research because it has a higher chance of resulting in additional income (e.g., running royalties or cashed-in equity, etc.) and would not hinder the development of scientists' academic career. Evaluating the impact of the new promotion system is out of the scope of this study. Nevertheless we would like to call university managers' attention to the possible negative influence of the modification of the academic promotion system.

For policy makers, it is important to adopt a policy that can successfully promote market uses of the research outcomes that have higher commercial potential but does not lessen university scientists' interest in basic science during the project selection stage. Our analysis shows that patent applicants tend to perceive a higher level of support by their Ph.D. institutions for research commercialization, and university scientists who receive Ph.D. training governed by the research commercialization policy do not report a greater degree of shifting their research orientation. It means that Ph.D. training might make prospective university scientists realize the value of research commercialization, but such training may not lead project selection to be driven by market considerations. Accordingly, governments should encourage industry-university cooperative research programs that require graduate students to be involved in or support industrial internship programs for graduate students so that those prospective university scientists can have more sense of how to integrate their scientific research with practical needs. On the other hand, government should review the appropriateness of their resource allocations for research and development. According to the statistics collected by the Ministry of Science and Technology, the ratio of approved research grants to grant applications by the Taiwan National Science Council has steadily decreased between 2004 and 2014. We contend that sufficient research funds from government are prerequisites of the academic freedom that allows university scientists to select research projects based on their scientific curiosity. Decreases in government funding may increase the dependence of university scientists on industry funds and might put long-term scientific progress in danger.

References

Abreu, M., and V. Grinevich. 2012. "The Nature of Academic Entrepreneurship in the UK: Widening the Focus on Entrepreneurial Activities." *Research Policy*, 42(2): 408-422.

Agrawal, A., and R. Henderson. 2002. "Putting Patents in Context: Exploring Knowledge Transfer from MIT." *Management Science*, 48(1): 44-60.

Ambos, T. C., K. Makela, J. Birkinshaw, and P. D'Este. 2008. "When Does University Research Get Commercialized? Creating Ambidexterity in Research Institutions." *Journal of Management Studies*, 45(8): 1424-1447.

Arrow, K. J. 1962. "Economic Welfare and the Allocation of Resources for Invention." In Universities-National Bureau eds., *The Rate and Direction of Inventive Activity: Economic and Social Factors*. Cambridge, MA: The National Bureau of Economic Research, 609-626.

Azoulay, P., W. Ding, and T. Stuart. 2007. "The Determinants of Faculty Patenting Behavior: Demographics or Opportunities?" *Journal of Economic Behavior & Organization*, 63(4): 599-623.

Azoulay, P., W. Ding, and T. Stuart. 2009. "The Impact of Academic Patenting on the Rate, Quality and Direction of (Public) Research Output." *The Journal of Industrial Economics*, 57(4): 637-676.

Baldini, N. 2006. "The Act on Inventions at Public Research Institutions: Danish Universities' Patenting Activity." *Scientometrics*, 69(2): 387-407.

Bercovitz, J., and M. Feldman. 2007. "Academic Entrepreneurs and Technology Transfer: Who Participates and Why?" In Malerba, F., and S. Brusoni eds., *Perspectives on Innovation*. Cambridge, UK: Cambridge University Press, 381-398.

Bercovitz, J., and M. Feldman. 2008. "Academic Entrepreneurs: Organizational Change at the Individual Level." *Organization Science*, 19(1): 69-89.

Bercovitz, J., and M. Feldman. 2011. "The Mechanisms of Collaboration in Inventive Teams: Composition, Social Networks, and Geography." *Research Policy*, 40(1): 81-93.

Blumenthal, D., E. G. Campbell, M. Gokhale, R. Yucel, B. Clarridge, S. Hilgartner et al. 2006. "Data Withholding in Genetics and the Other Life Sciences: Prevalences and Predictors." *Academic Medicine*, 81(2): 137-145.

Breschi, S., F. Lissoni, and F. Montobbio. 2008. "University Patenting and Scientific Productivity: A Quantitative Study of Italian Academic Inventors." *European Management Review*, 5(2): 91-109.

Buenstorf, G. 2009. "Is Commercialization Good or Bad for Science? Individual-level Evidence from the Max Planck Society." *Research Policy*, 38(2): 281-292.

Bush, V. 1945. *Science: The Endless Frontier*. Washington: US Government Printing Office.

Carayol, N. 2007. "Academic Incentives, Research Organization and Patenting at a Large French University." *Economics of Innovation & New Technology*, 16(2): 119-138.

Chang, Y.-C., M.-H. Chen, M. Hua, and P. Y. Yang. 2005. "Industrializing Academic Knowledge in Taiwan." *Research Technology Management*, 48(4): 45-50.

Chang, Y.-C., M.-H. Chen, M. Hua, and P. Y. Yang. 2006. "Managing Academic Innovation in Taiwan: Towards a 'Scientific-economic' Framework." *Technological Forecasting and Social Change*, 73(2): 199-213.

Chang, Y.-C., M.-H. Chen, and P. Y. Yang. 2006. "A study of Industrializing Academic Knowledge in Taiwan: Opportunities and Challenges for Entrepreneurial Universities." *Sci-Tech Policy Review*, 1: 2-11.

Chang, Y.-C., and P. Y. Yang. 2008. "The Impacts of Academic Patenting and Licensing on Knowledge Production and Diffusion: A Test of the Anti-commons Effect in Taiwan." *R&D Management*, 38(3): 321-334.

Chang, Y.-C., P. Y. Yang, and M.-H. Chen. 2009. "The Determinants of Academic Research Commercial Performance: Towards an Organizational Ambidexterity Perspective." *Research Policy*, 38(6): 936-946.

Chang, Y.-C., and M.-N. Chen. 2011. "On Transformation of Public Sector Research: A Preliminary Post-STBL Assessment in Taiwan." *Technological Forecasting and Social Change*, 78(3): 498-513.

Colyvas, J., M. Crow, A. Gelijns, R. Mazzoleni, R. R. Nelson, N. Rosenberg et al. 2002. "How Do University Inventions Get into Practice?" *Management Science*, 48(1): 61-72.

Dai, Y., D. Popp, and S. Bretschneider. 2005. "Institutions and Intellectual Property: The Influence of Institutional Forces on University Patenting." *Journal of Policy Analysis and Management*, 24(3): 579-598.

Fabrizio, K. R., and A. Di Minin. 2008. "Commercializing the Laboratory: Faculty Patenting and the Open Science Environment." *Research Policy*, 37(5): 914-931.

Göktepe, D. 2008. *Inside the Ivory Tower: Inventors and Patents at Lund University.* Doctoral dissertation, Department of Design Sciences, Lund University.

Geuna, A., and L. J. J. Nesta. 2006. "University Patenting and Its Effects on Academic Research: The Emerging European Evidence." *Research Policy*, 35(6): 790-807.

Glenna, L. L., R. Welsh, D. Ervin, W. B. Lacy, and D. Biscotti. 2011. “Commercial Science, Scientists’ Values, and University Biotechnology Research Agendas.” *Research Policy*, 40(7): 957-968.

Grushcow, J. M. 2004. “Measuring Secrecy: A Cost of the Patent System Revealed.” *The Journal of Legal Studies*, 33(1): 59-84.

Heller, M. A., and R. S. Eisenberg. 1998. “Can Patents Deter Innovation? The Anticommons in Biomedical Research.” *Science*, 280(5364): 698-701.

Huang, W.-L., M. Feeney, and E. Welch. 2011. “Organizational and Individual Determinants of Patent Production of Academic Scientists and Engineers in the United States.” *Science and Public Policy*, 38(6): 463-479.

Ismail, K., C. Mason, S. Cooper, W. Z. W. Omar, and I. A. Majid. 2008. “The Actors Involved and the Decision-making Process Used in the Exploitation of University Patents.” *International Journal of Business and Information*, 3(2): 165-192.

Jensen, R. A., J. G. Thursby, and M. C. Thursby. 2003. “Disclosure and Licensing of University Inventions: The Best We Can Do with the S**t We Get to Work with.” *International Journal of Industrial Organization*, 21(9): 1271-1300.

Kumar, M. N. 2010. “Ethical Conflicts in Commercialization of University Research in the Post-Bayh-Dole Era.” *Ethics & Behavior*, 20(5): 324-351.

Larsen, M. T. 2011. “The Implications of Academic Enterprise for Public Science: An Overview of the Empirical Evidence.” *Research Policy*, 40(1): 6-19.

Levin, S. G., and P. E. Stephan. 1991. “Research Productivity over the Life Cycle: Evidence for Academic Scientists.” *The American Economic Review*, 81(1): 114-132.

Merton, R. 1942. “The Normative Structure of Science.” In Merton, R. eds., *The Sociology of Science.* Chicago, IL: The University of Chicago Press, 267-278.

Moutinho, P. S. F., M. Fontes, and M. M. Godinho. 2007. “Do Individual Factors Matter? A Survey of Scientists’ Patenting in Portuguese Public Research Organisations.” *Scientometrics*, 70(2): 355-377.

Mowery, D. C., R. R. Nelson, B. N. Sampat, and A. A. Ziedonis. 2001. “The Growth of Patenting and Licensing by U.S. Universities: An Assessment of the Effects of the Bayh-Dole Act of 1980.” *Research Policy*, 30(1): 99-119.

Mowery, D. C., and A. A. Ziedonis. 2002. “Academic Patent Quality and Quantity before and after the Bayh-Dole Act in the United States.” *Research Policy*, 31(3): 399-418.

Mowery, D. C., B. N. Sampat, and A. A. Ziedonis. 2002. “Learning to Patent: Institutional Experience, Learning, and the Characteristics of U.S. University Patents after the Bayh-Dole Act, 1981-1992.” *Management Science*, 48(1): 73-89.

Murray, F., and S. Stern. 2007. “Do Formal Intellectual Property Rights Hinder the Free Flow of Scientific Knowledge? An Empirical Test of the Anti-commons Hypothesis.” *Journal of Economic Behavior & Organization*, 63(4): 648-687.

Nelson, R. R. 1959. “The Simple Economics of Basic Scientific Research.” *Journal of Political Economy*, 67(3): 297-306.

Nelson, R. R. 2004. “The Market Economy, and the Scientific Commons.” *Research Policy*, 33(3): 455-471.

Nulty, D. D. 2008. “The Adequacy of Response Rates to Online and Paper Surveys: What Can Be Done? ” *Assessment & Evaluation in Higher Education*, 33(3): 301-314.

Renault, C. S. 2006. “Academic Capitalism and University Incentives for Faculty Entrepreneurship.” *The Journal of Technology Transfer*, 31: 227-239.

Sampat, B. N. 2006. “Universities and Intellectual Property: Shaping a New Patent Policy for Government Funded Academic Research.” In Guston, D. H., and D. Sarewitz eds., *Shaping Science and Technology Policy: The Next Generation of Research*. Madison, WI: The University of Wisconsin Press, 55-76.

Siegel, D. S., D. A. Waldman, L. E. Atwater, and A. N. Link. 2004. “Toward a Model of the Effective Transfer of Scientific Knowledge from Academicians to Practitioners: Qualitative Evidence from the Commercialization of University Technologies.” *Journal of Engineering and Technology Management*, 21(1-2): 115-142.

Slaughter, S., C. J. Archerd, and T. I. D. Campbell. 2004. “Boundaries and Quandaries: How Professors Negotiate Market Relations.” *The Review of Higher Education*, 28(1): 129-165.

Stephan, P. E., S. Gurmu, A. J. Sumell, and G. Black. 2007. “Who’s Patenting in the University? Evidence from the Survey of Doctorate Recipients.” *Economics of Innovation and New Technology*, 16(2): 71-99.

Stokes, D. E. 1997. *Pasteur’s Quadrant: Basic Science and Technological Innovation*. Washington, D.C.: Brookings Institution Press.

Strandburg, K. J. 2005. “Curiosity-driven Research and University Technology Transfer.” In Libecap, G. D. et al. eds., *University Entrepreneurship and Technology Transfer: Process, Design, and Intellectual Property* (Advances in the Study of Entrepreneurship, Innovation and Economic Growth, Volume 16). San Diego, CA: ELSEVIER Inc, 93-122.

Stuart, T. E., and O. Sorenson. 2005. “Social Networks and Entrepreneurship.” In Alvarez, S. A., R. Agarwal, and O. Sorenson eds., *Handbook of Entrepreneurship Research: Disciplinary Perspectives*. New York, NY: Springer, 211-228.

Thursby, J. G., and M. C. Thursby. 2002. “Who Is Selling the Ivory Tower? Sources of Growth in University Licensing.” *Management Science*, 48(1): 90-104.

Thursby, M., J. Thursby, and S. Gupta-Mukherjee. 2007. “Are There Real Effects of Licensing on Academic Research? A life Cycle View.” *Journal of Economic Behavior & Organization*, 63(4): 577-598.

Van Looy, B., J. Callaert, and K. Debackere. 2006. “Publication and Patent Behavior of Academic Researchers: Conflicting, Reinforcing or Merely Co-existing?” *Research Policy*, 35(4): 596-608.

Walsh, J. P., and H. Huang. 2014. “Local Context, Academic Entrepreneurship and Open Science: Publication Secrecy and Commercial Activity among Japanese and US Scientists.” *Research Policy*, 43(2): 245-260.

研發成果商業化政策的反思：台灣教授對於基礎研究的興趣是否產生移轉？*

黃婉玲**

摘 要

本文旨在探討於研發成果商業化的政策系絡下，台灣大學教授的研究屬性，是否有從基礎科學研究移轉至應用科學研究的現象。本文針對 474 位台灣科學及工程領域的大學教授進行問卷調查，調查樣本包含 2005 年 6 月至 2010 年 6 月間曾申請過台灣專利，以及截至調查時間為止，從未申請過台灣專利的大學教授。研究結果顯示，與其博士論文的研究屬性相較，大學教授目前所執行的研究計畫，有較為偏向應用研究的趨勢；但此研究屬性的轉變幅度尚屬適度，並未全然忽視基礎研究。此外，本研究亦發現，於科學技術基本法通過施行前即取得博士學位及有業界工作經驗的大學教授，目前所執行之計畫較為偏向應用研究。

關鍵詞：研發成果商業化政策、基礎科學研究、應用科學研究、研究興趣的移轉、大學專利

* 本文分析資料係承科技部專題研究計畫「學術知識產業化對科學家研究議題選擇之影響」（NSC 101-2410-H-032-015-MY2）經費補助。
** 淡江大學公共行政學系助理教授，電子郵件：whuang24@mail.tku.edu.tw。

收稿日期：103 年 8 月 25 日。接受刊登日期：104 年 2 月 5 日。