THE INFLUENCE OF ENTREPRENEURIAL ACTIVITIES ON TEACHING AT UNIVERSITIES IN THE UNITED STATES

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THE INFLUENCE OF ENTREPRENEURIAL ACTIVITIES ON TEACHING AT UNIVERSITIES IN THE UNITED STATES

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LIST OF ABBREVIATIONS

AUTM	Association of University Technology Managers
BDA	Bayh-Dole Act
Carnegie R1 university	A university classified as a Carnegie Research 1 institution
CMC	Computer-mediated communication
MIT	Massachusetts Institute of Technology
NIH	National Institutes of Health
NS&E	Natural science and engineering
NSB	National Science Board
NSOPF	National Study of Postsecondary Faculty
OLS	Ordinary least squares
R&D	Research and development
SAB	Scientific advisory board
TTO	Technology transfer office
UIC	University of Illinois at Chicago
US	United States

SUMMARY

This study is to investigate the influence of entrepreneurial activities on teaching at universities. Specifically, the study focuses on entrepreneurial activities' effect on professors' time allocation. The dataset analyzed was constructed from the survey conducted by University of Illinois at Chicago in 1998. The sample was drawn from American academic professional associations' members of the four fields: experimental biology, physics, mathematics, and sociology.

Based on the data of 133 professors, the study shows that professors with paid consulting work tend to spend less time in teaching when research activities are controlled. Insignificant are the other variables about entrepreneurial activities: patent application, industry funding, and research collaboration with industry. Also, more research time is likely to result in less teaching time. Insignificant are the other research-related variables: research funding at large and collaborative research in general.

In terms of personal and institutional conditions, assistant professors tend to invest more time in teaching than senior professors, but they are likely to reduce more time on teaching than their senior counterparts for increasing research time. Finally, biology and sociology professors tend to allocate less time to teaching than physics and mathematics professors. In a word, entrepreneurial activities and research tend to conflict with teaching at the level of individual professors' time allocation.

CHAPTER 1

INTRODUCTION

Over several decades, universities have made active efforts to commercialize their resources including their scientific research, which is called entrepreneurial activities. Etzkowitz (2003, 2004) call entrepreneurial activities one of universities' missions with teaching and research. Universities with teaching as their first mission have included research as their second mission since the first academic revolution, which began in Germany in the late 19th century. The universities engaged in teaching and research has been called research universities. Similarly, Etzkowitz argues that the addition of entrepreneurial activities to universities' missions is the second academic revolution. University with the three missions is called "entrepreneurial university." (Etzkowitz et al. 1995)

The emergence of universities as entrepreneurs is closely connected with the increasing importance of knowledge production at the global level. The World Bank's World Development Report (1998) shows "from 1976 to 1996 the share of high- and medium-technology goods in global trade increased from about one-third to well above one-half." Especially, the share of high-technology goods showed the double increase from 11 to 22 percent. The phenomena can be translated into that "the knowledge component of goods and services becomes decisive" in the global economy (Castells 2000: 108-109). As scientific knowledge became critical for industrial competitiveness, universities engaged in knowledge production came to get attention as crucial institutions that can contribute to developing economy to the advanced level (Etzkowitz et al. 1995, Slaughter and Leslie 1997: 23-63).

Academic entrepreneurial activities have a goal of attracting funding and making profits based on higher education's resources, including scientific research.

Entrepreneurial activities can boost the commercialization of academic scientific research, which in turn can satisfy social needs that otherwise might not be fulfilled (AUTM 2006). However, given that higher education institutions as non-profit organizations had not been active entrepreneurs, entrepreneurial activities can have a negative influence on universities' traditional two missions; research and teaching. Academic researchers could be concerned more about profitable topics than about non-profitable ones. They might avoid open communication of their research with the fear that others could commercialize knowledge gained from the communication (Bok 2005, Nelson 2004, Thursby and Thursby 2003). Professors could care more about entrepreneurial activities than about teaching because the activities might make new monetary reward that teaching does not create (Slaughter and Leslie 1997).

Nonetheless, among teaching and research, teaching is more likely than research to be vulnerable to entrepreneurial activities' influence. This is because entrepreneurial activities stems primarily from scientific research. Thus, entrepreneurial activities cannot completely undermine research. On the other hand, given that tuition may be less elastic to teaching effectiveness, teaching students is less likely to contribute to entrepreneurial activities that aim at diverse funding and profit.

My research question is whether and to what extent professors' entrepreneurial activities negatively influence their investments in teaching. This topic is policy-relevant because it is concerned about the quality of teaching for students who pay tuition to learn. The students have the right to learn at least as much as the value of the tuition. This concern could be more serious for undergraduate education than for graduate one. This is because graduate education is for research and teaching, but undergraduate education is mainly for teaching. Given that the number of undergraduate students is much larger than that of graduate students, whether the students are well educated and trained is critical to society at large. The students will be the society's new workforce, and their qualification will be directly related to the society's future. In short, despite entrepreneurial universities' contribution to society by technology transfer, the contribution might be compromised by degraded education at the universities.

This study could contribute to filling the gap in higher education literature and entrepreneurship literature. Of the three missions of universities, the influence of entrepreneurial activities on research has been investigated by many scholars (Barnes and Bero 1998, Blumenthal et al. 1986, 1996, Bok 2005, Nelson 2004, Thursby and Thursby 2003, Walsh et al. 2005). There has been a lot of research on the relationship between research and teaching (Bok 2006, Braxton 1996, Braxton and Berger 1996, Fox 1992, Gottlieb and Keith 1997, Hattie and Marsh 1996, Kim et al. 2003, Lee and Rhoads 2004, Milem et al. 2000). On the contrary, there has been rare empirical research into the influence of entrepreneurial activities on teaching (Blumenthal et al. 1986, 1996, Lee and Rhoads 2004). In sum, investigating scarcely researched topic, this research will expand the scope of literature regarding higher education.

CHAPTER 2

ENTREPRENEURIAL ACTIVITIES, RESEARCH, AND TEACHING

Entrepreneurial activities' goals are attracting funding and making profits. The primary goal of research is advancing science by creating knowledge, and that of teaching is nurturing qualified students by transmitting knowledge. Given that the three types of activities have distinct goals, entrepreneurial activities can be in conflict with research and teaching. For example, extremely speaking, someone could argue that universities should achieve advancing science and educating students despite their monetary losses. This argument would be highly unlikely to be accepted by those emphasizing entrepreneurial activities.

This chapter is to review the trilateral relationship between entrepreneurial activities, research, and teaching. Before the review, the two types of entrepreneurial activities at universities are explained.

2.1 The Two Types of Entrepreneurial Activities

Universities' entrepreneurial activities can be divided into two types between indirect and direct commercialization of knowledge. The indirect commercialization of knowledge is characterized by universities' close relationship with industry, including contractual consulting for industry, conducting projects ordered by industry, and research collaboration with industry. Given that land-grant universities collaborated actively with agriculture industry in the United States (US) during the pre-1940 era (Mowery and Rosenberg 1993: 36-37, Morin 1993: 92-95), the indirect commercialization cannot be considered as a new phenomenon. However, the linkage between academia and industry became closer than before, especially as the government funding for universities' instruction and research has weakened since the 1980s (Bok 2005, Etzkowitz et al. 1995, Slaughter and Leslie 1997). For example, the portion of the federal government in academic research and development (R&D) funding decreased from 68.3 percent in 1972 to less than 60 percent in the last 1990s. During the same period, the portion of industry increased from 2.8 percent to more than 7 percent (NSB 2008: Figure 5-5 and Appendix Table 5-2).

The direct commercialization of knowledge is characterized by active pursuit of profit and managerial engagement in industry. The managerial engagement includes serving for a firm's scientific advisory board (SAB), holding a managerial position in the firm, and possessing equity in the firm (Krimsky et al. 1991: 278). At the professorial level, faculty members in biological sciences at top research universities were engaged managerially in biotechnology firms as early as the late 1980s. For instance, in the Department of Biology at Massachusetts Institute of Technology (MIT), more than 30 percent of its faculty had managerial affiliation with industry (Krimsky et al. 1991). Equity sales and holdings become important in some research universities' revenue stream. For example, in 1997, MIT "sold its equity in three star-up companies for $5.8 million. That compares very favorably with the $13.2 million they made that year on more than 400 traditional licenses." (Bray and Lee 2000: 386-387).

Universities have had their technology transfer offices (TTOs), which serve to pull technology out of research groups at universities. The roles of TTOs include the facilitation of patenting process and licensing patents to firms. Also, TTOs engage in creating spin-off firms based on academic research or its patents. With the support of TTOs and venture capital, "knowledge and technology [become] embodied in a firm and moved out of the university by an entrepreneur." (Etzkowitz 2004: 73) In short, the direct commercialization of knowledge means that professors and universities commercialize their scientific research and expertise by themselves beyond just providing industry with their expert knowledge.

In the US, the Bayh-Dole Act (BDA) adopted in 1980 stimulated universities' direct commercialization of scientific research. The Act encouraged universities to own patents arising from federally funded research and to license the patents exclusively (Boettiger and Bennett 2006, Etzkowitz et al. 2000, Thursby and Thursby 2003, Sampat 2006). Given that more than half of academic expenditure on R&D has been from the federal government (NSB 2008: Figure 5-5), it can be said that the BDA expanded the possibilities of direct commercialization. In other words, since the adoption of the BDA, universities and academic researchers can legally have funding from their own research as well as from other institutions.

In sum, as scientific knowledge became critical in economic development, universities as knowledge-producers came to engage actively in entrepreneurial activities. The activities are divided into two types: indirect commercialization of knowledge and direct one. The former includes academia's close relationship with industry, and the latter is active pursuit of profit. Academic entrepreneurial activities have been encouraged by the relative decline of government funding for higher education and by the adoption of the Bayh-Dole Act.

2.2 The Impact of Entrepreneurial Activities on Higher Education

Entrepreneurial activities at universities have contributed to national and regional economic development by realizing academic research's commercial potentialities. For example, the number of patents by research universities grew dramatically from less than 100 in 1965 to about 300 in 1980 to almost 1,600 in 1995. Universities' licensing income increased from below $0.2 billion in 1991 to over $1.2 billion in 2000 (Sampat 2006: 781-782). Besides patenting and licensing, university technology transfer has created many products that "made a better world," including "Honeycrisp apples, Google, the television V-chip, [and] nicotine patches." (AUTM 2006: 9-10) In 2003, 25 new biotechnology firms in the New Haven area were based on research conducted by Yale

University with funding from the National Institutes of Health (NIH) (Bruckbauer 2003: 1429).

Moreover, entrepreneurial activities might not necessarily be in conflict with research and teaching. Through a survey of 1238 biotechnology faculty members conduced in 1985 and that of 2052 life-science faculty members in 1995, Blumenthal and his colleagues (1986, 1996) find that those with industrial support for their research tend to publish more articles in refereed journals as well as to be more active in entrepreneurial activities than those without such support. Given that biological sciences can be considered as scientific fields in “Pasteur’s quadrant,” which both pursue fundamental understanding of nature and consider their research’s application (Stokes 1997), this finding indicates that research outputs and entrepreneurial activities could reinforce each other at least in some fields (see Blumenthal et al. 1986: 1364-1365).

In terms of teaching, the aforementioned studies find that those with industrial support are not significantly different from those without the support in teaching time (Blumenthal et al. 1986, 1996). Lee and Rhoads (2004) show that professors with consulting activities tend to be more committed to teaching. They suggest that professors engaged in consulting might gain some insights into instruction while they deal with real-world issues (Lee and Rhoads 2004: 754).

In spite of the aforementioned evidence of entrepreneurial activities’ positive effects, it cannot be denied that the same activities could cause an adverse effect on universities. Academic entrepreneurial activities can pose a threat to public image of and/or support for universities. Also, there is some evidence that entrepreneurial activities might negatively influence other missions of universities: research and teaching.

First, academic entrepreneurial activities can negatively influence public credibility of universities, although the activities’ economic contribution could enhance public image of academia as an engine of economic development. Besides funding from the government and industry, universities could gain royalty through licensing.

Furthermore, they might obtain profit from the success of spin-off firms. Hence, as universities become engaged more in entrepreneurial activities, their institutional images are likely to change from academia for fundamental knowledge to quasi-firms for their own profit. The public could consider universities less trustworthy because, like industry, their position could be based not on disinterested understanding of nature and society but on their economic gain. "In public iconography, *shabby* gentility is just as characteristic of the professoriate as absent-mindedness. It is all part of how academics are forgiven for being so smart. That quiet little social contract between ivory tower and general public is broken if the professor (or the institution) suddenly looks *rich* and clever." (Kennedy 1997: 12, Italic added)

Universities' research integrity is connected with this credibility issue. For instance, an analysis of 106 medical review articles shows that 94 percent of the articles whose authors has ties to the tobacco industry concluded that secondary smoking was not harmful to health, whereas only 13 percent of those without the ties reached the same conclusion. Even when the other four variables are considered, the affiliation with the tobacco industry is the only significant variable. The added variables include the articles' quality evaluated by two independent assessors, peer review status, topics about health risks caused by passive smoking, and year of publication (Barnes and Bero 1998). This finding indicates that universities' entrepreneurial activities could make academic research in favor of industrial interest. That is to say, universities' research integrity could be threatened by their close linkage with industry.

Second, even though entrepreneurial activities might not reduce academic publication productivity, universities' entrepreneurial activities might negatively affect the other aspects of scientific research. Entrepreneurial activities could make academic researchers pursue profitable and short-term research topics rather than non-profitable and long-term topics. For example, based on his research experience at Stanford University, Panofsky (1992: 144-145) argues that industry is more active than government agencies in making academic research topics closer to what they want. Moreover, professors engaged in entrepreneurial activities might come to prefer profitable research topics on their own. The 1985 and 1995 surveys of life-science faculty members find that those with research funding from industry (30 percent in 1985, 35 percent in 1995) are more likely than those without it (7 percent in 1985, 14 percent in 1995) to be affected by commercial applicability when they choose research topics (Blumenthal et al. 1986, 1996).

Also, the increasing possibility of commercializing scientific research could hinder academic researchers' open communication about research and exchange of research materials. Thursby and Thursby (2003) find that 44 percent of industry licensees requested their academic patentees to delay publication about the patents. Blumenthal and his colleagues (1996) find that faculty members with industrial support are more likely than those without it to refuse other academic researchers' requests for sharing research results or materials. Also, Walsh et al. (2005) show that academic researchers with commercial orientation tend to refuse requests to send materials that they research more than those without the orientation. Moreover, they find that 30 percent of academic scientists conducting research on signaling proteins, which are "patent-intensive research areas with enormous commercial interest," did not receive the material that they recently requested.

Especially, limited access to research materials may not only delay research using the materials but also make it impossible to conduct research requiring them. This issue could be more serious when the materials are used as research tools (Nelson 2004). The case of GenPharm demonstrates the limited access' influence on scientific research, although the firm's tools were not invented in academia. During the early 1990s, GenPharm charged at least $80 per its patented mouse and prohibited academic researchers from breeding the mice, which made biomedical scientists take an action to widen the access to research tools (Marshall 2000). These effects of entrepreneurial activities on research can distort the development of scientific knowledge.

Last but not least, there are some possibilities that entrepreneurial activities can adversely influence teaching. This is because, like long-term research, teaching does not make profit in the short term. As mentioned earlier, since the 1980s, government funding for higher education has weakened with national emphasis on industrial competitiveness. Especially, the decrease of government's block grant has reduced universities' discretion to spend their revenue, and government auditors have begun to scrutinize how government funding is used (Ehrenberg et al. 2003, Slaughter and Leslie 1997). It became necessary for universities to expand the scope of funding sources, to compete for funding with each other, and to commercialize their resources such as scientific research results. Accordingly, universities came to put more revenues in entrepreneurial activities to attract funding. This change tends to lead the revenues spent in instructions to decrease. This is partly because tuition revenue is more stable than other funding sources that depend on competition with other universities and market uncertainty (Slaughter and Leslie 1997).

For example, universities have made considerable efforts to recruit prominent scholars because the scholars can attract more funding as well as contribute to reinforcing universities' academic reputation (Bok 2005, Ehrenberg 2006). The aforementioned financial change has made it more difficult to recruit eminent scholars with government funding. The money for hiring the scholars became dependent on universities' internal funding. Finally, "the weighted average percentage of total research expenditures per faculty member being financed out of institutional funds rose from 11.2 percent to 20.7 percent" from 1970 to 2000. The expenditure for attracting the scholars was likely to increase undergraduate students' tuition and to decrease the ratio of students to faculty (Ehrenberg et al. 2003). The constraint of financial resources is likely to increase the number of part-time and full-time non-tenure-track professors rather than that of tenure-track ones. This change of faculty composition tends to decrease the graduation rate, a proxy of the quality of education (Ehrenberg and Zhang 2005).

Furthermore, universities came to encourage their members to attract revenue from various sources. Consequently, they came to value the members contributing to increasing revenue. Hence, professors can be motivated to engage in entrepreneurial activities more than in teaching (Slaughter and Leslie 1997). The valuation of entrepreneurial activities can be strengthened at the level not only of universities but also of individual professors.

To summarize, entrepreneurial activities at universities is too important to be ignored. Entrepreneurial activities have significantly realized the commercial possibilities of academic research. Some evidence shows that academic entrepreneurial activities are positively related to research productivity. However, the activities could compromise universalities' public credibility and threaten academic research integrity. Also, entrepreneurial activities might weaken long-term R&D capability by valuing short-term and profitable research. The activities could hinder academia's open communication about research and access to research materials. Finally, entrepreneurial activities could adversely affect teaching because, like long-term research, teaching is unlikely to make profit in the short term.

2.3 Teaching and Research

While there has been little empirical research on the effect of entrepreneurial activities on teaching (Blumenthal et al. 1986, 1996, Lee and Rhoads 2004), scholars have unceasingly investigated the relationship between research and teaching at universities. The previous research can help understand the relationship between entrepreneurial activities and teaching. This is because, given that entrepreneurial activities are based mainly on research, the relationship between research and teaching can have something in common with that between entrepreneurial activities and teaching.

Extremely speaking, the influence of research on teaching might explain most of entrepreneurial activities' influence.

Research and teaching might be incompatible with each other. Some scholars argue that professors tend to be less concerned about their students than they should be because they are likely to value producing new knowledge more than transmitting established knowledge (Bok 2006, Getman 1992, Smith 1991). Even though a professor value both research and teaching, he or she has limited time and energy to invest. This "scarcity model" argues that this limitation tends to prevent professors from harmonizing research with teaching (Hattie and Marsh 1996).

Some conditions of universities can contribute to reproducing this relatively deficient concern for teaching. When universities hire professors or evaluate them to decide their tenure, teaching has been considered less seriously than research as an evaluation factor (Bok 2005, Getman 1992). Graduate students, many of whom will be future academic instructors, do not have sufficient opportunities to consider how they teach students well. "In the eyes of most faculty members in research universities, teaching is an art that is either too simple to require formal preparation, too personal to be taught to others, or too innate to be conveyed to anyone lacking the necessary gift." (Bok 2006)

In addition, all kinds of teaching are not equally treated. Professors are inclined to desire to disseminate their expert knowledge to other people, especially their students. Hence, they tend to prefer teaching their expert area of concentrations. On the other hand, they are likely to pay less attention to teaching introductory knowledge and indispensable skills for academic life, including writing and discussion technique. Accordingly, the less valued teaching burden tends to be "turned over to a cadre of graduate students and part-time adjunct teachers distinguishable chiefly by meager compensation, loose supervision, and insufficient training for the task." (Bok 2006)

A meta-analysis of 58 empirical studies shows that time on teaching is negatively related to time on research and to publication productivity (Hattie and Marsh 1996). In some research, professors who emphasize teaching's importance tend to produce fewer publications, and professors who are more interested in research than teaching are likely to spend more time in research and less time in teaching (Fox 1992a, Gottlieb and Keith 1997). Also, professors with funded research tend to be less committed to teaching. If a professor's university has higher research expenditure, he or she is likely to have less commitment to teaching (Lee and Rhoads 2004).

However, research does not necessarily conflict with teaching. Instructors' discussion of current research allows students to understand the real-world application of theories in the textbook. Also, advanced research could update and modify course curriculum. Conversely, teaching can be helpful to research because instructors have an opportunity to discuss their research with students. Through the discussion, instructors could clarify their research concepts and gain fresh insights from students (Braxton 1996: 6-7, Hattie and Marsh 1996: 511-512).

In addition, research shares something with teaching. For example, research requires organizing task and integrating data, and teaching also requires organizing materials. Organizing something is one of the key common factors for both research and teaching. This common factor could help a good researcher be a good teacher (Hattie and Marsh 1996: 516-518). In a word, there are even possibilities of achieving "joint production efficiencies" for research and teaching (Rhoades 2001: 623).

Through their meta-analysis, Hattie and Marsh (1996) show that the overall relationship between research output and teaching quality is almost zero but slightly positive. Most studies that they analyze use student evaluation as a measure of teaching quality and the number of publications as a proxy of research output. They also show that neither teaching time nor research time is related to teaching quality. Similarly, in the meta-analysis of Braxton (1996), only one study shows that research productivity tends to conflict with teaching effectiveness among 30 empirical studies analyzed. In short, both meta-analyses argue that research output and teaching quality are likely to have no relationship.

In addition, studies show that research productivity does not negatively affect student-faculty interactions or teaching practice and contents. For instance, professors with higher research productivity do not have less office hours. Highly productive professors are not more likely to prefer lecture to discussion. Moreover, professors active in publication are more likely to introduce recent scholarly publications at the class than those passive in publications (Braxton and Berger 1996).

In terms of faculty members' time allocation, the international comparative study of Gottlieb and Keith (1997) shows that time on teaching is associated positively with time on research. Milem and his colleagues (2000) demonstrate that both teaching and research time increased for about 20 years since 1972. A study shows that universities' research expenditures have a positive effect on undergraduate students' graduation (Kim et al. 2003).

In sum, while research and teaching could be beneficial with each other, universities' reward system and culture can make professors value research more than teaching. Although this dynamic between research and teaching could not be directly applied to the relationship between entrepreneurial activities and teaching, it is still meaningful to understand the dynamic. This is because the dynamic points out that valuing one mission of universities can affect another mission. Entrepreneurial activities could make universities' culture more pro-profit and pro-business. Especially in natural science and engineering fields, professors' income and their department's revenue do not fully depend on teaching students. If entrepreneurial activities are more appreciated in universities, the quality of teaching might deteriorate due to research community's growing lack of concern for it.

CHAPTER 3

RESEARCH DESIGN

This chapter explains what dataset and methods are used. Variables used in this study are described with the reasons why they are adopted. Finally, hypotheses are presented.

3.1 Dataset and Methods

This study's dataset is constructed from the survey conducted by Walsh and his colleagues with University of Illinois at Chicago (UIC) in 1998. The survey's respondents are scientists, who are drawn from the 1997 membership directories of the Federation of American Societies of Experimental Biology, American Physical Society, American Mathematical Society, and American Sociological Association. The survey primarily aimed at investigating the disciplinary difference in computer-mediated communication (CMC) and the relationship between CMC and scientists' work pattern and research productivity (Walsh et al. 2000).

Although this dataset was not initially designed to evaluate the influence of professors' entrepreneurial activities on their teaching, the dataset has enough, if not complete, information to analyze the influence. The dataset includes information about scientists' time allocation, academic field, funding source, and collaboration. This is why this study uses the dataset of Walsh and his colleagues.

Among the 1998 UIC dataset's 333 observations, this research chooses only faculty members. The number of the professors is 190. There are 133 observations that have full information for the variables considered in this study. 43 observations are not included in the sample because the observations' data are missing for time on teaching, having a collaborator from industry and doing paid consulting work. Time on teaching is this study's dependent variable, and the other two variables are independent variables for entrepreneurial activities.

This study uses the ordinary least squares (OLS) multiple regression models. The dependent variable is time spent in teaching, which is an interval level variable. The independent variables are about professors' entrepreneurial activities, research activities, and personal and institutional conditions.

3.2 Variables

3.2.1 Dependent Variable

This study's dependent variable is the respondent's time spent in teaching, including grading and preparing for courses. Time on teaching is used as an operational variable of professors' investments in teaching. Academic activities, including teaching, are labor-intensive, so time is one of a professor's valuable resources. Along with time on research, time on teaching can show how professors allocate their time to manage distinct academic activities.

Needless to say, professors' time on teaching cannot represent all the aspects of their teaching activities. Although Gottlieb and Keith (1997) shows that a professor with more interest in teaching than research spends more time in teaching, time on teaching is not a direct measure of a professor's attitude toward teaching. Hence, it is hard to say that professors' dedication to teaching can be estimated by time on teaching.

Furthermore, professors' increasing time spent in teaching does not necessarily promote their students' understanding of what the professors teach. As mentioned earlier, many studies conducted mostly in the 1970s have reported that teaching time does not seriously influence teaching quality as measured by student evaluation (Hattie and Marsh 1996). Furthermore, unless professors choose effective teaching methods, their increasing time on teaching might not make a difference in their students' understanding. In fact, few studies about research-teaching relationship are concerned about student learning (Hattie and Marsh 1996, Verburgh et al. 2007).

For example, many instructors attempt to change traditional “lecture-then-test” format (Powell 2003). The new attempts include inquiry-based teaching like seminar and undergraduate students’ research activities (Handelsman et al. 2004, Powell 2003, Wood 2003). At Rutgers University, it was so effective to emphasize students’ group work at its introductory physics courses that the portion of the female freshmen who choose engineering majors increased almost twice from 1985 to 1993 (Brahmia and Etkina 2001). This result indicates the possibilities that professors who spend relatively less time in teaching could raise their students’ understanding with effective pedagogical methods.

Nonetheless, the introduction of inquiry-based teaching format usually necessitates monetary support and instructors’ devotion, which are highly affected by university-wide priority setting. Given that inquiry-based teaching is not used as widely as lecture-then-test especially for undergraduate courses, the change of teaching format tends to require more time than expected because professors need to spend more time in figuring out how they apply inquiry-based format to the settings where the format has not been used. Therefore, if professors do not spend enough time in teaching, any teaching method seems unlikely to be effective. In short, time on teaching might represent teaching effectiveness, especially given a recently growing concern about teaching format. However, the possibility still does not change the fact that time spent in teaching is not a direct indicator of teaching quality.

3.2.2 Independent Variables

This study’s independent variables are divided into three types: professors’ entrepreneurial activities, research activities, and personal and institutional conditions. Except time on research, the independent variables are dummy variables. Table 1 describes the summary statistics of the variables considered in this research, and Table 4 shows the correlation matrix of the variables. The variables' coding scheme is explained in Table 3.

As for entrepreneurial activities, four variables are considered: whether the respondent applied for a patent based on his or her research within the past five years, whether the respondent receives research funding from industry, whether the respondent has a research collaborator from industry, and whether they do paid consulting work. Patent application is chosen because patenting is one of the symbols of universities' entrepreneurial activities, especially since the Bayh-Dole Act's adoption. Industry funding and collaborators are selected because universities' closer relationship with industry is a feature of entrepreneurial university. Paid consulting work can be included in entrepreneurial activities that aim at broadening revenue sources.

This study uses the four variables for entrepreneurial activities in the same model. This is because the four variables are not highly correlated with each other. As shown in Table 4, the correlation coefficients between any two of the variables are smaller than 0.07. Also, the coefficients are not significant at the 5 percent level.

As for research activities, three variables are chosen: time spent in research, whether the respondent receives any research funding, and whether the respondent engages in any collaborative research. Time on research is chosen because it shows how professors allocate their time to deal with various academic activities, some of which could be just duties. This is the same reason for choosing time on teaching as the dependent variable. Funding from any source is included because funded researchers need to be accountable to their funding agencies, which tends to make the researchers care more about the funded research. Participation in collaborative research is selected because collaborative research could increase non-research activities, including communication with collaborators.

Moreover, these funding and collaboration variables are necessary to understand the effects of funding from and collaboration with industry. Whether academic researchers engage actively in entrepreneurial activities or not, they have received funding from the government or non-profit foundations and joined collaborative research at large. Industry funding is also funding, so funding from industry can have something in common with that from the other types of sources. Likewise, having research collaborators from industry can share something with having those from the others. Thus, the effects of industry funding and collaborators can be duly evaluated when those of funding and collaborative research at large are controlled.

In addition, this analysis does not use the number of the respondent’s published papers in referred journals within the past two years as an independent variable. This is to avoid the variable’s multicollinearity with time spent in research, which is one of the independent variables. It is frequently reported that academic researchers’ number of published papers is positively correlated with their time on research (Fox 1992a, Gottlieb and Keith 1997, Hattie and Marsh 1996). This study’s sample shows the high correlation between the papers’ number and time on research. As shown in Table 4, the correlation coefficient between the two variables is close to 0.45 and significant at the 1 percent level. The simultaneous use of these two highly correlated variables will negatively affect their statistical significance.

In fact, the number of published papers has been used as an indicator of research productivity because journal papers have served as a major codified vehicle to communicate with other scientists (Fox 1983: 285, Zuckerman 1992: 41-43). Also, the number can represent time on writing, which might not be included in this study’s time on research. However, time on research is much more crucial in this study than published papers’ number. This is because time on research influences time on teaching more directly than the papers’ number. These are why the respondent’s number of published paper is not considered.

Finally, as for personal and institutional conditions, three variables are considered: gender, being an assistant professor, and the respondent’s academic field.

With respect to gender, it is reported that female professors tend to spend more time in teaching or have more commitment to teaching than their male counterparts (Gottlieb and Keith 1997, Lee and Rhoads 2004). With regard to academic rank, assistant professors can have more courses to teach than senior professors, including associate and full professors. If tenure evaluation emphasizes teaching effectiveness as well as research performance, this organizational pressure can lead assistant professors to spend more time in teaching. Also, assistant professors are less likely than the senior counterparts to have enough experience in teaching, which makes them less efficient in managing teaching burden than their senior counterparts.

When it comes to professors' academic fields, this study follows the classification of academic fields that is used by Walsh and his colleagues (1996, 2000). The fields are experimental biology, physics, mathematics, and sociology. Biological research exemplifies universities' entrepreneurial activities with active formation of spin-off firms and its large portion in university-owned patents and licensing income (PCAST 2003: 8-11, Powell and Owen-Smith 2002).

Because of the small observations in those fields, this study treats physics and mathematics as one reference group for the respondent's academic field. Although the two fields of natural sciences can be categorized into pure non-life fields, which have less concern with application and with "life systems" (Biglan 1973a, b), physics and mathematics professors can have different work organization, which could result in distinct organizational culture. Given that physicists have experienced large-scale experiments, like those at Fermi National Accelerator Laboratory, much more than mathematicians (Walsh and Bayma 1996), physicists can be more accustomed to the central coordination of research units for a research project. Those organizational differences can influence professors' time allocation, but the differences' effect is not this study's focal point. This study focuses primarily on academic entrepreneurial activities, so the difference between biology and the two non-life fields is more meaningful than the difference between physics and mathematics. Walsh and Bayma (1996) also point out that experimental biology and chemistry are more market-oriented than physics and mathematics.

Last but not least, sociology represents non-natural-science fields. Even though entrepreneurial activities occurring in natural science and engineering (NS&E) field has gained attention, the activities are strongly connected with changing pattern of funding flow into academia. This means that non-NS&E fields also have need for entrepreneurial activities (Slaughter and Leslie 1997).

Even though the Carnegie Classifications of Institutions of Higher Education could be meaningful as an independent variable representing the respondent's conditions, the variable is not included in this study's models. Like the case of published papers' number, this is to exclude the variable's multicollinearity with time spent in research, which is the independent variable that directly correlates with time on teaching. Given that top 20 higher education institutions in R&D expenditure have occupied more than quarter of total academic R&D expenditure (NSB 2008: Figure 5-11), it can be said that universities with higher Carnegie rank are likely to spend more R&D expenditure, which tends to promote their professors' commitment to research.

Table 4 shows the high correlation between the respondent's time on research and affiliation with a Carnegie Research 1 (R1) university in this study's sample. In 1998 when the UIC survey was conducted, the R1 university class is the highest one among research universities'. The correlation coefficient between the two variables is more than 0.40 and statistically significant at the 1 percent level. Using these two highly correlated variables in the same model will reduce their statistical significance.

3.3 Hypotheses

My research question is whether and to what extent universities' entrepreneurial activities negatively influence teaching at the level of individual professors. Accordingly, the main hypothesis is that professors' growing entrepreneurial activities decrease their time spent in teaching when other variables, including research activities, are controlled. Especially, controlling for research activities is to exclude the influence of entrepreneurial activities that have something in common with research activities.

As for professors' activities, another hypothesis is that professors' increasing research activities reduce their time spent in teaching when other variables, including entrepreneurial activities, are controlled. This hypothesis is to address ongoing discussion about the relationship between research and teaching at universities.

As for personal and institutional conditions, three hypotheses are tested. The first hypothesis is that female professors invest more time in teaching than male professors. The second hypothesis is that assistant professors spend more time in teaching than senior ones. The third hypothesis is that professors engaged in biology invest less time in teaching than the other fields. This hypothesis is based on the fact that biology has been the exemplary field of entrepreneurial activities.

Table 1. Summary Statistics

Variable		Mean	Std. Dev.	Min	Max
Dependent Variable	Time on teaching	22.476	14.918	0	80
Personal And Institutional Conditions	Female	0.218	0.415	0	1
	Biology	0.285	0.453	0	1
	Sociology	0.406	0.492	0	1
	Assistant professor	0.248	0.434	0	1
	Carnegie R1	0.526	0.501	0	1
Entrepreneurial Activities	Patent application	0.128	0.335	0	1
	Industry funding	0.015	0.122	0	1
	Industry collaborator	0.030	0.171	0	1
	Paid consulting	0.128	0.335	0	1
Research Activities	Time on research	22.211	17.900	0	100
	Published paper	3.338	3.017	0	16
	Funding	0.436	0.498	0	1
	Collaborator	0.692	0.464	0	1

Note 1: Std. Dev. is the abbreviation of standard deviation.
Note 2: The sample size is 133.

CHAPTER 4

FINDINGS AND DISCUSSION

The regression result is described in Table 2. The model (1) includes the variables about personal and institutional conditions and those about entrepreneurial activities. The model (2) has two more variables about research activities than the model (1). The two variables are funding from any source and participation in collaborative research. The model (3) has one more variable about research activities than the model (2). The variable added to the model (3) is the respondent's time on research. The models (4) and (5) include the interaction terms between entrepreneurial activities and academic field and between research activities and academic rank. This paper usually evaluates independent variables' statistical significance at the 5 percent level. If 5 percent is not used as the significance level, it is explicitly written what percent level is adopted.

4.1 The Effect of Entrepreneurial Activities on Teaching Time

As for entrepreneurial activities, as shown in the model (1), professors who have applied for a patent tend to spend less time in teaching than those who have not. However, as shown in the models (2) and (3), the negative effect of patent application becomes weaker as more variables about research activities are included in the models. The addition of the research variables also weakens the statistical significance of patent application's effect. Eventually, patent application is not significant even at the 15 percent level in the models (3), (4), and (5).

Given that all research-related variables tend to have a negative influence on teaching time in the sample, it can be said that patent application positively correlates with research activities. In other words, research funding and collaborative research could contribute to patent application, and time on research could be spent in writing patents.

This inference indicates that all entrepreneurial activities are not incompatible with research activities.

On the contrary, the effect of paid consulting on time spent in teaching becomes significant with the addition of research-related variables, especially time on research. The effect of paid consulting is not significant in the models (1) and (2) even at the 15 percent level. However, in the model (3) with time spent in research, paid consulting's effect is statistically significant. That is to say, controlling for time on research, professors with paid consulting work tend to spend less time in teaching than those without it.

The model (2) shows that the negative effect of paid consulting becomes weaker when research funding and collaboration in general are controlled. On the contrary, in the model (3), the negative effect of paid consulting becomes stronger when time on research is included in the model. All the variables about research activities tend to reduce time on teaching in the sample, so it may be argued that, in the sample, paid consulting correlates positively with research funding or collaboration while it is related negatively to research time. In other words, professors with research funding or collaborators tend to have paid consulting work, while paid consulting work can reduce time on research. These inferences suggest that some entrepreneurial activities can adversely affect research activities.

This finding about consulting work is contradictory to that of Lee and Rhoads (2004). As mentioned earlier, they shows that professors with consulting activities tend to have more commitment to teaching than those without them. This apparent contradiction can come from various reasons. Professors' strong commitment to teaching might not necessarily lead to longer time on teaching. For instance, professors with less teaching burden can be likely to spend less time in teaching, no matter how much strong their commitment to teaching is. Also, while this study's variable is "paid" consulting, Lee and Rhoads do not explicitly state whether their consulting variable is only about paid consulting or about consulting activities in general. The effect of consulting activities needs to be investigated in future research.

Finally, funding from and collaboration with industry is not significant even at the 15 percent level in the models (1), (2), and (3). The finding about industry funding is consistent with that of Blumenthal and his colleagues (1986, 1996). They find that life-science professors with research funding from industry do not differ from those without the funding in teaching time.

Despite the similarity between this study's finding and that of Blumenthal and his colleagues, two studies seem to measure teaching time in a different manner. This study's teaching time includes grading and preparing. In other words, the variable tries to include time on teaching regular courses. On the contrary, in the study of Blumenthal et al., teaching time is "the average number of hours per week of teaching contact with predoctoral and postdoctoral trainees (including students, interns, residents, and fellows)" (Blumenthal et al. 1996: 1736) or "the average number of hours of contact per week [including laboratory supervision] with graduate students or postdoctoral fellows." (Blumenthal et al. 1986: 1363) Although it is unknown how many hours this study's respondent invests in undergraduate education and advising, the variable of Blumenthal et al. seems to be mostly about graduate advising. These findings indicate that industry funding might negatively influence neither graduate education nor undergraduate education. This hypothesis needs to be tested by future research.

Furthermore, F-test for the model (3) cannot reject the hypothesis that having industry funding or industry collaborators does not influence the respondent's time spent in teaching. Thus, the models (4) and (5) do not use industry funding and collaborators as their independent variables.

Despite the insignificance of those variables, it is worth to mention that professors with industry funding invest more time in teaching than those without it in this study's sample. This result could be influenced by the small observations that have relationship with industry. In the sample, the number of professors with industry funding or collaborators is less than 10. Overall, these findings at least show that the research funding source or collaborators' affiliation does not make a serious difference in professors' time on teaching.

In sum, some of this study's findings support the hypothesis about entrepreneurial activities. Paid consulting work tends to lead college professors to reduce time on teaching. Patent application, industry funding, industry collaborators are insignificant when time on research is controlled.

4.2 The Effect of Research Activities on Teaching Time

As for research activities, in the model (2), professors with research funding from any types of source tend to spend less time in teaching than professors without it. However, in the model (3) with time on research, research funding at large is not significant even at the 15 percent level. Either in the model (2) or (3), participation in collaborative research is statistically insignificant.

The model (3) shows that the negative effects of funding and of collaborative research become weaker when time on research is included. Given that more time on research is likely to decrease time on teaching in this study, it can be argued that either funding or collaborative research correlates positively with time on research. In other words, having research funding or collaborators can increase time on research.

This positive relationship between funding and research time can give an insight into the finding of Lee and Rhoads (2004) that professors with funded research significantly have less commitment to teaching. This study shows that research funding is insignificant when time on research is considered. In Lee and Rhoads' study, having funded research might be insignificant if their study considered another variable about research activities, like the respondent's commitment to research. These inferences indicate that the multicollinearity of time on research with other research activities needs to be carefully dealt with.

Time on research is the only significant variable about research activities. The variable is significant even at the 0.1 percent level. College professors who invest more time in research tend to lower their time on teaching. However, one-hour increase of time on research tends to decrease time on teaching by less than one hour. Even in the model (3), where the negative strength of research time in the sample is the strongest among the models, the maximum effect in the population is 0.503 given the 95 percent confidence interval. That is to say, when professors increase research time by one hour, they tend to reduce teaching time by about a half hour in an extreme case.

These findings about the trade-off between research time and teaching time are consistent with those of Hattie and Marsh (1996). Their meta-analysis shows that time on research is negatively related to time on teaching, but "it is probable that there is not a one-to-one compensation when research time is increased at the expense of teaching time." (Hattie and Marsh 1996: 509) The findings imply that professors can raise their time on research by lowering not only time on teaching but also time on other activities, including administration at universities or family life. Future research about professors' time allocation needs to consider time spent in various activities other than teaching and research.

In short, this study's findings provide some support for the hypothesis about research activities. More time on research is associated with less time on teaching. Research funding and collaborative research at large are not significant when time on research is included in the model.

4.3 The Effect of Personal and Institutional Conditions on Teaching Time

As mentioned above, personal and institutional conditions are gender, academic rank, and academic fields. After the findings about being female and being an assistant professor are explained, those about academic fields are described. Especially, this part explains why the interaction terms between being an assistant professor and research time and between being a sociologist and paid consulting are included in the model.

4.3.1 The Effects of Gender and Academic Rank

As for personal conditions, female professors tend to spend more time in teaching than male professors in the sample, but gender is not significant even at the 15 percent level. Nonetheless, the sign of gender's impact on teaching time is consistent with the finding of Gottlieb and Keith (1997).

In the models (2) and (3), as more research-related variables are added to the models, the positive effect of being female becomes stronger. Given that all of research-related variables are correlated negatively with teaching time in this sample, it can be said that being female is correlated positively with research activities in the sample. That is to say, at least in this sample, female professors are more likely than male professors to have research funding or collaborative research and to spend more time in research.

The inference about research funding and collaboration is different from previous studies' findings that female academic researchers are less likely than their male counterparts to apply for grant and to participate in collaborative research (Fox 1992b, Zuckerman 1992: 42-43). This study's inference about research time indicates that female professors might invest more time both in research and in teaching than male professors, controlling for the other variables. Future research needs to test these inferences.

Being an assistant professor is significant in all the models considered. Assistant professors tend to spend more time in teaching than senior professors. However, as mentioned above, this result does not show why assistant professors invest more time in teaching. This is partly because, in this study, there is no variable for professors' actual teaching loads. In other words, whether assistant professors are responsible for more courses than senior ones is unknown. As mentioned earlier, this result could be also from the importance of teaching effectiveness in tenure evaluation or from assistant professors' relative inexperience in teaching. Future research needs to consider plural factors that cause the difference of teaching time by academic rank.

The models (2) and (3) show that, as more research-related variables are included in the models, the positive effect of being an assistant professor becomes weaker. Considering that all of research-related variables tend to have an adverse influence on teaching time in the sample, it can be said that assistant professors are less likely than the senior counterparts to have research funding or collaborators in the sample. It can be also said that, at least in this sample, assistant professors tend to have less time on research than senior ones. That is to say, assistant professors tend to have more teaching time and less research time than senior professors, controlling for the other variables.

The inferences from the models (2) and (3) suggest that the time allocation pattern of assistant professors could be different from that of senior professors. As mentioned earlier, assistant professors in the sample tend to have fewer resources for research than their senior counterparts. If their department values research more than teaching, especially in tenure evaluation, assistant professors with less funding and fewer collaborators can become more dependent on another investment: time on research. While professors need to survive severe competition with others for research funding or collaborators, they can control their time on their own. Given that assistant professors tend to spend more time in teaching than senior professors, assistant professors might reduce more time on teaching than the senior counterparts to guarantee more time on research. This is why this study tests the interaction term between being an assistant professor and time on research.

In the models (4) and (5), the interaction term is significant at the 1 percent level. F-test for the model (5) shows that the interaction term significantly improves the model. When they increase time on research, assistant professors are likely to decrease more time on teaching than senior professors. In the sample, assistant professors tend to reduce

0.67 hours on teaching for one more hour on research, but senior ones tend to decrease 0.28 hours on teaching. Given the 95 percent confidence interval, in the population, assistant professors are likely to reduce about an hour on teaching to increase research time by one hour in an extreme case. Also, in the models (4) and (5), assistant professors tend to invest more time in teaching by almost half a day per week than senior professors in the sample when they have no time on research.

These findings do not demonstrate why assistant professors reduce more time on teaching to increase time on research. As mentioned above, assistant professors might depend heavily on increasing research time to compensate for a lack of research funding and collaborators. Senior professors could spend more time in administration for their department or college than assistant professors, so they might reduce time on administration instead of time on teaching for more time on research. Future research needs to investigate how professors' time allocation changes by academic rank with more comprehensive data about their time spent in plural activities, including administration.

4.3.2 The Effects of Academic Fields

Academic fields' effects on teaching time are significant. Professors engaged in biology tend to spend less time in teaching than those in physics and mathematics, which are included in pure non-life field. Furthermore, professors engaged in sociology tend to invest less time in teaching than the two pure non-life sciences. Lee and Rhoads (2004) also show that not only faculty members in biology but also those in social sciences are less committed to teaching. This similarity between Lee and Rhoads' finding and this study's is discussed later with the framework of Biglan (1973a, b).

In the model (3), when time on research is controlled, the negative effect of being a biologist or a sociologist becomes weaker. Because research time is likely to decrease teaching time, it can be argued that both biology and sociology professors tend to have more research time than the others, at least in the sample. However, in the model (2), the effect of being a biologist does not change in the same direction as that of being a sociologist. When research funding and collaboration are controlled, the negative impact of biology becomes weaker, whereas that of sociology becomes stronger. Given that all of research-related variables correlate negatively with time on teaching in the sample, this difference means that, at least in the sample, biology professors are more likely to have research funding or collaborators, but sociology professors are less likely to have them.

Despite this different relationship with research funding and collaboration by academic field, biology professors' time on teaching might be very similar to sociology professors' when the other variables are controlled. F-tests for the models (3) and (5) fail to reject the hypothesis that biology professors spend the same time in teaching as sociology professors. This means that, at least from the perspective of professors' time allocation for research and teaching, the difference between biology and sociology can be far smaller than that between either of the two fields and the pure non-life sciences, which are physics and mathematics.

These findings suggest that, in some cases, the difference within natural sciences can be larger than that between natural and social sciences when entrepreneurial and research activities are controlled. According to Biglan (1973a, b), biology and sociology are more concerned about "life systems" than physics and mathematics, so biology and sociology are life areas while the other two fields are non-life areas. Biglan (1973b) shows that life areas are less likely than non-life areas to prefer and to spend time in teaching, whereas life and non-life areas do not differ in preference for and time on research. He argues that life areas' professors tend to act "as a committee of the whole" in graduate education and to train graduate students in research settings, which can make life-area professors have less interest and time in teaching (Biglan 1973b: 211-212). Although his argument seems to be primarily about biological sciences, this study's finding about teaching time and that of Lee and Rhoads (2004) about commitment to teaching are consistent with that of Biglan. Future research needs to investigate what makes this disciplinary discrepancy.

To understand the impact of having sociology as the respondent's field, the interaction term between sociology as a field and entrepreneurial activities is tested in the model (4). Professors in social sciences are likely to attract less funding than those in natural sciences and engineering (see Slaughter and Leslie 1997: 240), so those in social sciences might spend more personal resources engaged in attracting funding and entrepreneurial activities. Time on teaching can be included in personal resources. Sociology professors in the sample have not applied for patents within the past two years at the time of the survey, so this study chooses paid consulting work as the proxy of entrepreneurial activities for the interaction term with being a sociologist.

The impact of the interaction term between being a sociologist and paid consulting is negative in the sample, which means that sociology professors with paid consulting work reduce more time on teaching than others with the work. However, the interaction term is not significant even at the 15 percent level. The difference in R-squared between the models (4) and (5) is negligible, which shows that the interaction term does not improve the model.

In sum, two of the three hypotheses about personal and institutional conditions are supported in this study. Being female is insignificant, but assistant professors are likely to spend more time in teaching than their senior counterparts. Biology and sociology professors are likely to invest less time in teaching than physics and mathematics professors, controlling for the other variables.

Table 2. Multiple Regression of the Time Spent in Teaching

	(1)	(2)	(3)	(4)	(5)
Female	0.899	2.377	3.140	2.989	2.935
	(0.32)	(0.86)	(1.28)	(1.26)	(1.24)
Biology	-12.061**	-11.837**	-7.271*	-7.344*	-7.178*
	(3.72)	(3.68)	(2.45)	(2.56)	(2.53)
Sociology	-6.339*	-7.657**	-6.167*	-6.080*	-6.315**
	(2.29)	(2.84)	(2.56)	(2.54)	(2.72)
Assistant professor	7.904**	6.189*	5.601*	12.664**	12.724**
	(2.89)	(2.27)	(2.31)	(3.82)	(3.85)
Patent application	-9.335*	-6.698§	-3.181	-4.066	-4.037
	(2.46)	(1.79)	(0.94)	(1.25)	(1.24)
Paid consulting	-4.280	-3.571	-6.278*	-5.594	-6.664*
	(1.26)	(1.08)	(2.10)	(1.44)	(2.33)
Paid consulting x Sociology				-2.303	
				(0.41)	
Industry funding	5.495	7.994	8.253		
	(0.59)	(0.88)	(1.02)		
Industry collaborator	-1.631	0.191	-2.037		
	(0.24)	(0.03)	(0.35)		
Time on research			-0.374**	-0.280**	-0.279**
			(5.75)	(4.02)	(4.02)
Funding		-6.029*	-2.792	-1.750	-1.839
		(2.29)	(1.16)	(0.76)	(0.80)
Collaborators		-3.828	-1.660	-3.181	-3.156
		(1.43)	(0.69)	(1.36)	(1.36)
Time on research x Assistant professor				-0.388**	-0.390**
				(3.07)	(3.10)
Constant	28.035**	33.367**	36.802**	35.467**	35.514**
	(12.52)	(11.47)	(13.85)	(13.62)	(13.70)
R-squared	0.303	0.363	0.497	0.532	0.532
F-statistic (p-value)					
Industry funding = 0, Industry collaborators = 0			0.600		
			(0.552)		
Time on research x Assistant professor = 0					9.600
					(0.002)
Biology = Sociology			0.140		0.100
			(0.707)		(0.757)

§ significant at 10%; * significant at 5%; ** significant at 1%

Note 1: The sample size is 133.

Note 2: The value in parentheses for the independent variables is the absolute value of t statistics.

Note 3: The value in parentheses for F-statistic is the p-value.

CHAPTER 5

CONCLUSION AND FUTURE RESEARCH

In conclusion, this study shows that entrepreneurial activities negatively influence professors' time spent in teaching when research activities are controlled. Among the four variables for the activities, only paid consulting is statistically significant. Paid consulting work tends to decrease time on teaching. Research activities also tend to reduce teaching time when entrepreneurial activities are controlled. Among the three research-related variables, only time on research is significant. More time on research is likely to result in less time on teaching. Assistant professors tend to have more time on teaching than senior professors, but they tend to reduce more time on teaching than their senior counterparts for increasing research time. Finally, professors engaged in biology or sociology tend to allocate less time to teaching than those in physics or mathematics. In a word, entrepreneurial activities and research tend to conflict with teaching at the level of individual professors' time allocation.

Among the findings, this paper wants to emphasize that each entrepreneurial activity can have a different relation with research activities. In this study's sample, time on research correlates positively with patent application but negatively with paid consulting work. That is to say, professors with more time on research tend to apply for patent, but those with paid consulting tend to reduce research time. This finding suggests that entrepreneurial activities are not uniform. If a study focuses on only one facet of entrepreneurial activities, the study is highly likely to lose a big picture about the activities.

Also, this paper's another emphasis is on the role of paid consulting work in faculty members' time allocation. This study shows that only paid consulting is significant among the variables about entrepreneurial activities. Patent application, industry funding and collaborative research with industry are not significant. Compared with other entrepreneurial activities, paid consulting might have least in common with research and teaching. Simply speaking, research funding and collaborative research are basically about research, whether or not industry is engaged in them. On the contrary, paid consulting work might be too practical from academic researchers' view. More importantly, paid consulting work could require immediate performance much more than research at large, which includes industry-funded research. However, given that Lee and Rhoads (2004) find that consulting work is likely to enhance professors' commitment to teaching, the influence of consulting work remains to be seen.

Given some limitations of this research, future research needs to identify the following factors as thoroughly as possible: professors' teaching loads and time allocation, their affiliation and orientation to research, and their relationship with industry. Most of all, professors' actual teaching loads need to be identified as an independent variable. This is because professors' time for teaching depends much on how many courses they are responsible for. If this study's dataset had the information about teaching loads, personal and institutional conditions' influence on teaching time could be clearer to be understood.

In addition, it is necessary to identify professors' time on other activities except teaching and research. For example, Bland and her colleagues (2006) use faculty members' time on teaching, research, administration, service, and consulting for their analysis. Time on research can increase not only by decreasing time on teaching but also by reducing time on service. Time on entrepreneurial activities, including writing patents, can be considered to distinguish it from time on research. Comprehensive information about professors' time allocation could help to understand why assistant professors decrease more time on teaching than the senior counterparts for raising time on research. The information also can clarify why biology and sociology professors are different from physics and mathematics professors in teaching time.

Moreover, it could be required to subdivide time on research and that on teaching. Some of research-related activities could not be identical to research. For instance, Fox (1992a) divides time on research-related activities into three types: research and writing, reviewing articles, and professional correspondence. Even though professional correspondence might inspire researchers, Fox distinguishes the correspondence clearly from research and writing. If time on research in this study includes time on the correspondence, the effect of research time might be overestimated because it can include the effect of time on the correspondence.

Similarly, teaching time also has multiple elements. Fox (1992a) divides time on teaching-related activities into two types between course preparation and undergraduate advising. This study's time on teaching includes grading and preparing, but whether undergraduate advising is included cannot be known. Besides, time on teaching could include graduate advising. Graduate advising could be more compatible with research than with undergraduate advising, so time on undergraduate advising might be more sensitive than time on graduate advising to growing time on research.

In terms of professors' affiliation, it could be helpful to consider their university's ownership in this study. Academic entrepreneurial activities have been stimulated partly by the government's declining financial support for higher education (Ehrenberg et al. 2003, Slaughter and Leslie 1997). Thus, public universities could be more vulnerable to the financial change than private universities, which in turn might make professors at public universities reduce more time on teaching for entrepreneurial activities than those at private universities. Future research can gain another insight into faculty members' time allocation by including the ownership of their universities.

Also, this study's result can be influenced by the characteristics of the sample. The sample is chosen from the membership directories of four academic societies. The members tend to be at least as productive in research as non-members, so this study's analysis could be more about research-oriented professors than about professors in general. The sample selection can lead to the higher portion of Carnegie R1 universities' professors, which are about a half of this study's respondents.

For example, according to Milem and his colleagues (2000), professors generally increase both teaching and research time for about 20 years since 1972, whereas those at research universities decrease teaching time but increase research time. Similarly, the 1999 National Study of Postsecondary Faculty (NSOPF) also shows that professors at research and doctoral institutions spend less time in teaching and more time in research than those in general. They spend average 23.7 hours per week in teaching and 14.0 hours per week in research (Bland et al. 2006: 105). As shown in Table 1, this study's professors spend about 8 hours per week in research more than those at research and doctoral institutions in the 1999 NSOPF. This difference in the average time on research might result from the respondents' strong orientation to research. Future research needs to include professors from as various types of higher education institutions as possible for the comprehensive understanding of professors' time allocation.

Finally, future research needs to address carefully professors' relationship with industry. The reason why professors' industrial tie is insignificant in this study could be understood in the following three ways. First, industry funding in this study includes not only pure industry funding but also joint funding of industry and other institutions. Similarly, the dummy variable for industry collaborators is 1 if there is at least one research collaborator affiliated with industry. Thus, it can be said at best that the two variables weakly represent professors' tie with industry.

Second, the information about the actual amount of funding can help to discern whether funding source is significant. Funding recipients can be more concerned about larger scale of funding. Hence, if the scale of industry funding is far smaller than that of government funding, the industry funding is less likely to be influential on the recipients than the government funding.

Third, this research's dataset do not identify the degree of professors' managerial engagement, which is the crucial facet of direct commercialization of academic resources. The variables for the industrial tie in this study are mostly about indirect commercialization. Patent application could be about the direct commercialization, but patents also might be another side of publication productivity. In other words, patents and journal articles could go hand in hand given that both types of publication are based on research activities. In sum, the various aspects of professors' relationship with industry need to be considered in future research.

APPENDIX A

TABLES

Table 3. Variables and Coding Scheme

Variable	Coding Scheme
Dependent Variables	
Time on teaching (hours per week, on average) : including grading and preparing	Interval level variable
Personal and Institutional Conditions	
Female	1= Yes, 0= No
Biology	1= Yes, 0= No
Sociology	1= Yes, 0= No
Assistant professor	1= Yes, 0= No
Carnegie R1 : Carnegie Research 1 university	1= Yes, 0= No
Entrepreneurial Activities	
Patent application : Application for a patent based on the respondent's research within the past five years	1= Yes, 0= No
Industry funding : Research funding from industry	1= Yes, 0= No
Industry collaborator : At least one research collaborator from industry	1= Yes, 0= No
Paid consulting : Doing paid consulting work during the last month	1= Yes, 0= No
Research Activities	
Time on research (hours per week, on average)	Interval level variable
Published paper : The number of papers published in refereed journals within the past two years	Interval level variable
Funding : Research funding from any source	1= Yes, 0= No
Collaborator : Participation in collaborative research	1= Yes, 0= No

Note 1: The reference group for fields is physics and mathematics.
Note 2: The reference group for academic rank is associate and full professors.

Table 4. Intercorrelations between All Variables

Variable	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1 Time on Teaching	1.000													
2 Female	0.053	1.000												
3 Biology	-0.422**	-0.052	1.000											
4 Sociology	0.076	0.194*	-0.523**	1.000										
5 Assistant professor	0.317**	0.203*	-0.248**	0.128	1.000									
6 Carnegie R1	-0.481**	-0.010	0.367**	-0.166	-0.222*	1.000								
7 Patent application	-0.335**	-0.039	0.456**	-0.317**	-0.064	0.273**	1.000							
8 Industry funding	0.042	-0.065	0.059	-0.102	-0.071	0.117	-0.047	1.000						
9 Industry collaborator	-0.086	0.014	0.181*	-0.146	0.101	0.079	0.064	-0.022	1.000					
10 Paid consulting	-0.173*	0.016	0.107	0.050	-0.064	0.093	0.056	-0.047	-0.067	1.000				
11 Time on research	-0.591**	0.058	0.402**	-0.185*	0.158	0.409**	0.367**	0.037	0.052	-0.058	1.000			
12 Published paper	-0.484**	-0.041	0.377**	-0.292**	-0.233**	0.457**	0.421**	0.151	0.185*	0.069	0.438**	1.000		
13 Funding	-0.368**	0.050	0.350**	-0.295**	-0.154	0.288**	0.299**	0.141	0.112	0.118	0.414**	0.476**	1.000	
14 Collaborator	-0.245**	0.077	0.026	-0.078	0.220*	0.247**	0.158	-0.051	0.118	-0.037	0.281**	0.389**	0.390**	1.000

* significant at 5%; ** significant at 1%

Note 1: The sample size is 133.

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