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Article

Torn between Academic Publications and University–Industry Collaboration

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Abstract

University–industry collaboration (UIC) has grown so rapidly recently that the research resources embedded in universities are shared with external actors in more diversified applications. Researchers have discussed the importance of UIC, showing that UIC facilitates knowledge flows and creates more opportunities for new inventions or innovative research. However, when universities target high performance on both academic research and UIC commercial activities, academic researchers face pressure in balancing their efforts between academic research and technological applications. This study collects researcher-level data from National Taiwan University of Science and Technology (NTUST), one of the top science and technology universities in Taiwan. By observing researchers' performance in NTUST, we explore the role of personal tech-oriented capabilities, UIC involvement, and institutional UIC atmosphere. The data include information from 323 research faculties during 2007–11. The results show that technological capabilities positively impact personal academic performance, particularly for researchers with little external social capital. The institutional UIC culture can also be a resource that helps both experienced and inexperienced academic researchers strengthen their performance on academic work. The U-I cooperation in academic works is also a positive stimulus on their personal academic performance, while UIC project collaboration only positively impacts researchers with diversified UIC connections. However, researchers working with different UIC projects have to utilize different resources to strengthen personal academic performance.

Key words: university–industry collaboration; academic publication; patent; technological capability.

1. Introduction

The role of a university has changed, as researchers are now involved in not only basic academic research, but also technological applications. For most research institutions and universities, research and development (R&D) labs embedded in a university campus have accumulated various research resources that can be offered to industrial actors for practical applications. Governments have also initiated different incentives and policy mechanisms to encourage interactions between industrial actors and universities. Because of the execution of the Bayh–Dole Act, universities have the right to exchange university research resources with external industrial actors (e.g. Thursby and Thursby 2002; Schacht 2012). Academic inventors in a university have different alternatives to manage their R&D resources. Some policies aim to establish an entrepreneurship atmosphere in society, whereby a start-up firm seeks resources from universities (e.g. Knowledge Transfer Partnership in the UK) (Jones and Grimshaw 2012). Industrial actors can also find technical support or services from universities, with new incentives bringing forth new external resources for universities. From the view of a university, the external alliance with industrial actors can help universities to shape a professional position in being a partner for industries. These interactions can also bring specific types of financial benefits for universities. However, to reach a top ranking in the world, universities have to achieve high performance in academic publications,

as academic publications produced by internal academic researchers can help them gain a good reputation in their academic field.

As the dual goals in University–Industry Collaboration (UIC) and academic research are both important for universities, most researchers make great efforts to perform well in both activities. In order to facilitate UIC, universities encourage researchers to participate in different university–industry (UI) projects, including providing tech support, research resources, or commercial consulting services to industrial demand. Industrial actors may cooperate with academic researchers via UIC contracts or technology transfer contracts and finish specific R&D activities. Through these different connections, university resources can be more widely applied in the real world. Licensing income via technology transfer or the benefits received via spinoff activities may bring monetary support for the operation of universities. On the other hand, universities need to prove high research capability in order to gain research funding. As academic publications are still critical criteria to earn science and technology (S&T) funding from governmental research councils, academic researchers embedded in universities also have to put forth a lot of academic output, and not just UIC connections. These different incentives or policies encourage academia to balance between academic studies and practical applications.

When facing different types of challenges, academic researchers need to accumulate various characteristics and capabilities from U-I interactions, technological development activities, or utilize their institutional environment to maximum different performances. Our study explores whether university researchers can utilize their technological capability and UIC resources as drivers to increase their performance in academic research. We also investigate how important is an organizational UIC culture for academia's performance in academic publications. As different researchers have different external social capital and different cooperative partners, the study also explores the moderating role of external linkages. In other words, we examine whether personal capability or UIC involvement bring different impacts on their academic performance when individual researchers have differing external links.

2. Cooperation between universities and industries

2.1 Involvement in UIC activities

From the view of innovation system studies, the interactions among different stakeholders within a system can help them accumulate specific learning mechanisms embedded in the system. The interactive mechanisms facilitate knowledge flows and innovations among different actors in the system (Lundvall et al. 2002; Morgan 2004; Cooke 2001). Among all different linkages and interactions, the U-I cooperative mechanism is one of the critical issues for making the whole system apply new knowledge in the practical world. U-I cooperation allows a mixture of internal resources and external partnerships to forge industrial development toward a research and knowledge-intensive direction (Zucker et al. 2002; Bekkers and Freitas 2008; Jones and Grimshaw 2012), and it also leads academic inventors to realize the importance of the commercialization value of new technologies in the real world (Perkmann et al. 2013). As academic and academic research works within universities are like the knowledge base of an innovation system (Mowery and Sampat 2004), policy makers have to consider how to utilize such resources for all different actors. From the Bayh–Dole Act to technology transfer mechanisms, policy makers usually establish more incentives for both industrial actors and universities to facilitate the flows of academic resources between the two. This also helps innovative knowledge to transfer efficiently and to upgrade industrial development to a higher position.

U-I cooperation in academic publications also plays an important role in knowledge creation. Several past studies showed that academic papers published by a joint work of industrial actors and academic researchers gain higher citations (Hicks and Hamilton 1999; Lebeau et al. 2008). U-I cooperation in academic publications further provides a relative higher value for reference in later academic research. For universities, cooperative academic research is also a new driver that allows them to gain a better performance in commercializing activities (Tijssen 2006; Wong and Singh 2013). Turning to cooperation in technological development, UIC is also expressed in co-invented patents. Some empirical results also presented that academic inventors always play the roles of mediators to facilitate knowledge diffusion among stakeholders (Lissoni 2010; Lissoni et al. 2008), which shows the importance of UIC interactions for inspiring researchers to learn how a new technology should be developed from the perspectives of both basic science and users (Mansfield 1995; D'Este and Perkmann 2011). UIC participation may also explain how a researcher behaves during academic research work. To explore the role of UIC involvement on personal academic performance, this study constructs measurements of different UIC activities and examines their relationships.

2.2 Institutional drivers

Working environment and an embedded institutional culture both play critical roles for employees' working performances. In a department with an intensive and close linkage to industrial actors, academic faculties are able to utilize resources accumulated from previous interactions. However, for academic researchers without any UIC experience, they may face difficulties due to a lack of cooperating culture within their institution (Webster and Etzkowtiz 1998; Fiaz and Naiding 2012). In other words, well-established UIC procedures and agreements help academic faculties know how UIC facilitates innovation cooperation (Florida 1999; Shane and Somaya 2007; D'Este and Patel 2007). An organized system and accumulated resources also help researchers balance the pressures among UIC activities and academic work. When a department establishes good connections with external industrial actors to exchange research academic knowledge and gain funding support, such interactions bring monetary benefits that support further innovations by those academic faculties (Debackere and Veugelers 2005). A department's successful experience may influence how scholars adjust their attitude toward the external challenges in UIC work (Zheng, et al. 2013). Therefore, an institutional UIC culture may diminish the burden on a researcher's UIC performance and provide a good effort balance between UIC and academic publication output. Our model further examines whether the existence of good UIC atmosphere in an institution can strengthen personal academic performance.

2.3 The importance of diversified social capital

External diversified resources determine whether academia can establish differing external relational capital in UIC activities. Some past studies attempted to figure out how previous relational assets impact the performance of U-I collaboration (Núñez-Sánchez et al. 2012; Meyer 2006b, Hoang and Rothaermer 2005). The

accumulated relations mostly reduce the risk of cheating during the interaction (Narula and Hagedoorn 1999), and intensive interactions may help to establish mutual trust and familiar routine for further cooperation (Dahl and Pedersen 2004; Lambercht and Pirany 2005). In other words, academic researchers with a diversified external relational asset may achieve a better UIC performance, such that they can take the UIC activities as resources to improve their research work. On the other hand, researchers with few external connections may need to put forth more efforts on UIC activities that could create lower cooperative benefit. This results in bringing fewer resources for personal academic research. Taking personal relational resource, e.g. social capital, as the internal resource embedded in a researcher, we learn that an internal resource might mitigate the relationships between collaboration and knowledge creation (Lavie and Drori 2012). Social capital seems to play a moderating role that explains why some scholars can perform better than others. In this study, we further investigate whether the diversity of external relational resources becomes the moderator to influence the relationship between UIC involvement and personal academic performance.

3. Technological capabilities and academic research

Previous studies have different answers on whether researchers participating in tech-oriented studies can also produce a high performance in academic work. Under different incentives from governments or universities, researchers face pressures from internal and external evaluations in their academic publication performance and U-I linkages. Academic researchers thus need to balance between their efforts on academic research and technological capabilities.

One side of the coin believes that time and efforts on tech-oriented applications may distort the capabilities in academic work (Allen 1977), and that study further explained that two types of researchers have different preferences on sharing their innovation outputs. One prefers to work more on basic academic or academic work and tends to publish a paper, whereas the other, with engineer characteristics, likes to develop technological capabilities for industrial demand. When academic researchers work on solving problems for industrial partners, a new discovery or invention for industry may fulfill a short-term market preference. In such a circumstance, the academic performance of scientists may be lower. Some academic researchers also have the obligation to conform to a confidential rule embedded in U-I contract research, which does not allow them to publish any relevant discovery (Dasgupta and David 1985). Agrawal and Henderson (2002) focused on the behaviors of 236 academic inventors working for Massachusetts Institute of Technology (MIT) during the period 1983–97. Their result shows that a researcher's performance in patent outputs does not significantly affect the performance in academic publications.

The other side of the coin stresses that capability can be complimentary, which turns into a driving force for both technology and academic research work (Van Looy et al. 2004). Owen-Smith (2003) applied the concept of a hybrid regime to express that the two approaches are both important for universities. Between commercial and academic success, one realm depends upon success in the other. Van Looy et al. (2006) also empirically explained that there is no evidence for a trade-off relationship between academic publications and application studies. They investigated researchers in a Belgium university (Catholic University of Leuven) and found that researchers involved in contract research published more papers than their colleagues in the control sample without application contract studies. This result shows a complementary relationship between research and application at a researcher level. A cross-sectional data set collected by Stephan et al. (2007) also found that a researcher's patent numbers are positively related to his/her quantity of publications. Another empirical study (Calderini and Franzoni 2004) also showed that a researcher's patenting activities significantly impact not only publication quantity, but also publication quality. Meryer's (2006a,b) observations in several European countries also noted that inventor-researchers produce better academic performance than non-inventor researchers. A doctoral study by Dai (2007) presented a co-productive relationship between patents and publications in the short term, but the relationship changes from the long-term perspective. This implies that a researcher's tech-oriented capabilities for academic publications might vary under different circumstances.

From the view of UI communication, academic inventors seem to gain different ideas from industries. When academic actors can communicate with industrial actors with sufficient technological knowledge, these interactions induce new technologies that can be extended to new applications. Academic inventors who have worked on new technological applications and development shorten the distance between industrial actors and researchers. Lissoni (2010) empirically showed that academic inventors play as mediators or brokers to facilitate knowledge flows between university and industry. These academic inventors, being capable of producing new technologies for commercialization or new application, gain more opportunities to interact with industrial actors. Thus, UI interactions bring different research ideas to researchers. Empirical research based on Chinese universities also found that academic researchers holding patents exhibit better performance in academic publications than those who do not possess patents (Guan and Wang, 2010).

Within this article's context for National Taiwan University of Science and Technology (NTUST), we aim to investigate whether technological-oriented capabilities matter for personal academic research performance. NTUST has special characteristics in fulfilling industrial demand and reaching academic goals. Historically, scholars have shaped the UIC culture within the university. However, the new policy in the funding program also evaluates researchers through their academic publications, and so it brings new challenges for the researchers to balance between technological application and academic work. The empirical model herein takes NTUST as the case to examine the technological capabilities that can either be drivers or roadblocks for efforts on research work.

4. UIC activities in NTUST

NTUST, established in 1974, is Taiwan's first higher education institution in the national technical and vocational education system. The university is located in central Taipei with an enrollment of more than 10,000 students, including undergraduate and graduate students, and 500 full-time faculties in 2013. As tech-oriented development and UIC are always the main missions of the university, NTUST has accumulated a plethora of high-quality research output. After Taiwan initiated a law similar to the Bayh–Dole Act in 1996, NTUST has taken a leading role in UIC activities (e.g. technology

transfer) among professional schools in Taiwan. NTUST is positioning itself to fulfill the demand for human capital, technologies, and services from industrial fields. The location of NTUST also brings many opportunities to interact with industrial players in Taipei's Neihu Technology Park, where the university provides physical space for start-up companies. In addition, NTUST's engineering-oriented characteristics can also provide good observation to explain the researchers' behaviors within the specific background as previous study outlined the role of engineering background (Rosenberg and Nelson, 1994). The unique UIC culture within NTUST is one of the reasons we take NTUST as the case to investigate our research topic. Table 1 shows the growing trend of UIC activities in NTUST. Cooperative projects between NTUST and industries present an increasing trend in the past few years.

Established four decades ago, the university initially aimed at fulfilling the demand for industrial actors. NTUST provides professional education, and the intensive UI connections that take place on campus allow students to conduct real work during their study time there. In recent years, the university has adjusted its goals toward gaining high performance not only in tech- and application-oriented UIC activities, but also in academic performance. The two different goals from Taiwan's Ministry of Education, *Top University Program* and *Paradigm Tech University Program*, drive NTUST to consider the balance between tech-oriented development and academic research. The former supports more research-oriented activities to help a university become a top one in the world, whereas the latter emphasizes the importance of UIC and interactions. Among all top universities in Taiwan, NTUST is the only one funded by both programs. Under these supportive conditions, academic researchers are also facing challenges at balancing their research efforts between UIC contract research and academic research. As the governmental funding programs provide different incentives that may change researchers' behaviors, NTUST is a proper case to construct data sets from which we can better observe how researchers balance their pressures between tech-oriented effort and academic work. This is the other reason we use NTUST for exploring whether researchers can turn tech-oriented capabilities and their UIC involvement into new drivers in order to create better academic performance.

5. Methodology and data

5.1 Data collection

In order to show whether the university researchers do balance between the different types of forces, i.e. tech-oriented and academic-oriented goals, we collect data from one of the top technology universities in Taiwan, NTUST. The scholars at this university are required to achieve high research performance goals from both academic and tech-application perspectives. Taking each scholar as the unit of analysis in the model, the total valid sample includes 323individuals. The time period of U-I contract information is from 2007 to 2011, with all personal information collected via different sources. One of the sources is the university R&D office, from which we extract personal involvement in UIC contract projects. In addition, we also collect publication data from the Web of Science (WoS) database to illustrate personal academic performances and from the UIC joint publications with industrial actors during the same period. Some of the missing data are collected directly from the website information, including gender and institutional variables. We apply multiple regression models and moderator examination testing to examine the role of technological capability and UIC activities.

5.2 Variables

In this study, we aim to explain whether a researcher's efforts in conducting UIC and in executing tech-oriented applications can facilitate his/her academic output. The model includes variables from personal information and the institutional factor. Table 2 summarizes the variables, and Fig. 1 shows the relationship we aim to examine in the empirical models.

The first part focuses on measuring personal technological capabilities. Based on past studies, several empirical models have applied the number of patents to show personal efforts on technological-oriented application (Lim 2004; Dai 2007). This study also takes personal patenting behaviors to show an academic researcher's technological capabilities. The model considers patenting activities from the 5-year period of 2006–11. In addition, we collect tech capability from two sources. One is from the domestic patent office (Dom_Pat), showing the number of patents applied by a specific researcher in Taiwan. The other variable is about international patenting activities (Int_Pat) by the researcher. We use the number of patents that a researcher applied in international patent offices. We also identify the researcher's background before working for the university to represent technological capability. Therefore, we set this variable, personal industry experience (I_experience), as a dummy variable, which helps to understand the impacts of personal practical experience on academic performance.

The second part measures UIC involvement at the personal level and institutional level. Two indicators represent *Personal involvement in UIC* activities. One is the UIC contract research hosted by the researchers, and the other is from cooperation in paper publications. For the research project part, both the number of contracts and the monetary value of contracts can be used to show UIC participation. However, because academic researchers may need more efforts or time to work on a high monetary value contract, the monetary value of a project is a relatively better indicator for showing

Table 1. UIC activities at NTUST

Indicator	2005	2006	2007	2008	2009	2010	2011	2012
U-I Collaboration								
Number	270	290	251	238	252	324	353	424
Amount*	$13.5 M	$16.5 M	$18 M	$21 M	$29 M	$30 M	$37 M	$43 M
Technology transfer								
Number	27	32	30	77	67	65	101	135
Amount	$0.3 M	$0.4 M	$0.5 M	$0.8 M	$0.5 M	$0.6 M	$0.9 M	$1.0 M

M = million US dollars (USD).

personal UIC involvement (UIC_Proj). As the importance of co-publication has been discussed in several past studies (e.g. Wong and Singh 2013), UIC involvement in academic studies should also be considered. Therefore, the other UIC involvement is measured from cooperation in research papers (UIC_Paper). We try to identify the number of academic papers (from WoS) that are worked on by both industrial actors and NTUST faculties. Apart from UIC involvement at the personal level, the study also measures *UIC organizational atmosphere* in the working environment (UIC_Inst). The research model aims to examine whether personal UIC involvement and institutional UIC culture are both critical for personal academic work.

To examine the moderating effects of researcher's external social capital, we have two types of moderators. The first one concerns the diversification of social capital, and the second one is about the characteristics of cooperative partners. For the first one, we classify the sample into two groups. One group includes those researchers with highly diversified social capital, and the other group includes researchers with little or zero social capital (Table 2). Regression models are used to test whether the two groups have different results. We also consider the characteristics of cooperative partners on a researcher's behaviors. Researchers who only work on private UIC projects or who only work for public UIC projects are selected to test the differences.

For the dependent variable, we use research publication data to represent personal academic performance. We extracted the data from the WoS database (Acade_Perf) for the time period covering 2006–11. According to previous studies, the indicator represents an academic researcher's performance and efforts in academic

Table 2. Descriptions of variables

Variables	Description		Source
Dependent variables			
Academic research performance	**Acade_Perf**	Number of academic publications	WoS
Independent variables			
(1) Personal tech. capabilities	Dom_Pat	Domestic patent number	NTUST
	Int_Pat	International patent number	
	I_Experience	Does the scholar have industrial experience before working in NTUST? (Yes: 1; No: 0)	
(2) UIC effort/involvement	UIC_Paper	Amount of U-I cooperation in academic works, i.e. number of UIC publications	WoS and NTUST
	UIC_Proj	UI project momentary value of the UIC project carried out by academia	
(3)Institutional UIC culture and environment	**UIC_Inst**	Number of UIC papers completed in a department	WoS
Moderator			
External linkages	(1)Diversification	Academia are classify into different groups: Number of connections with external actors in public, private, and researcher institution sectors. ***High***: Researcher has 2 or more connections. ***Low***: Researcher has1 or zero connection.	NTUST
	(2) UIC Cooperative partners (Public vs. Private)	We apply the characteristics of cooperative partners to identify different research groups. **Public** UIC: Researchers have only worked on UIC projects from public sectors. **Private** UIC: The researchers only work on the UIC projects from private sectors.	
Control	Dep_Eng	Institutional factor; Dummy variable to express the effect of the engineering department (Eng. dep: 1, others: 0)	NTUST
	Gender	Researcher's gender; Dummy variable (male: 1; female: 0)	

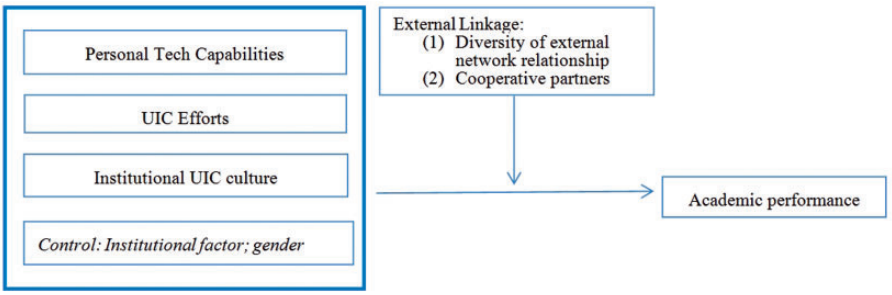

Figure 1. Research framework.

Table 3. Correlation matrix

	Mean (SE)	Dom_Pat	Int_Pat	I_Experience	UIC_Proj	UIC_Paper	UIC_Inst	Gender	Dep_Eng	Acade_Perf
Dom_pat	1.54 (3.58)	1	.689**	0.117*	.261**	.203**	.062	.133*	.028	.296**
Int_Pat	1.16 (3.40)	.689**	1	0.092	.166**	.225**	.062	.101	.054	.277**
I_Experience	0.29 (0.46)	0.117*	0.092	1	0.004	0.073	0.054	−0.046	−0.089	0.012
UIC_Proj	3.33# (9.24)	.263**	.166**	0.004	1	.097	−.013	.106	.044	.153**
UIC_Paper	.21 (0.60)	.203**	.225**	0.073	.097	1	.120*	.051	.045	.216**
UIC_Inst	7.03 (5.98)	.061	.062	0.054	−.013	.120*	1	.179**	.231**	.243**
Gender	.88 (0.33)	.132*	.101	−0.046	.106	.051	.179**	1	.020	.188**
Dep_Eng	.94 (0.24)	.026	.052	−0.089	.044	.045	.231**	.020	1	.053
Acade_Perf	9.39 (12.56)	.299**	.279**	0.012	.153**	.216**	.243**	.188**	.053	1

*P < 0.05; **P < 0.01; #: million in New Taiwan Dollar (NTD).

publication work (Meyer 2006a; Van Looy et al. 2004; Stephan et al. 2007). Because more than 90% of researchers in the data set belong to the engineering field, the measurement we used expressed their academic performance, rather than scientific performance. Personal academic publication is used to construct the dependent variable. Some past studies showed that females have fewer interactions or informal consulting with the private sectors (Corley and Gaughan 2005; Link et al. 2007), and people in engineering departments tend to interact with industrial actors (Ponomariov 2008). We further identify personal background, including personal gender and engineering department as the control variables, in the model. The full regression models examine the roles of technological capability, UIC involvement, and institutional factor for personal academic performance. To examine the impact under different social capital circumstances and different cooperative partners, our model also tests whether personal external linkages play a moderating role between these factors and personal academic performance.

6. Empirical examinations and discussion

6.1 Correlation and distribution

In the correlation matrix, the dependent variable, *Acade_Perf*, is significantly related to most of the independent variables, except the dummy variable, Dep_Eng, indicating whether the scholar belongs to an engineering department (Table 3). We also find a significant positive correlation between personal patenting activities and the researchers' UIC involvement. The UIC culture at the institutional level is also positively related to male researchers, engineering departments, and personal academic performance, but not significantly related to personal technological capabilities. In other words, in this data set, our researchers with high technological capabilities or those conducting high-value contract research are distributed randomly in departments with a different UIC culture. As NTUST is an S&T university, the distributions of gender and working department (engineering departments) are much skewed. In this data set, male researchers are 87.62% and female researchers are 12.38%. About 93% of researchers belong to engineering departments, and 7% of researchers are from others, e.g. design school or management school. As Rosenberg and Nelson (1994) explained, some certain field, e.g. engineering, involves more in U-I interactions. Because of the special data sets, the results can be properly applied to institutions with a similar background, e.g. engineering-oriented type, but may not be suitable for explaining the phenomena in other special types of institutions, e.g. those that are research-oriented.

Table 4. Examination for all samples

Dependent Variable: **Acade_Perf**	Model 1a	Model 1b	Model 1c	Model 1d
Constant	–	–	–	
Tech capability				
Dom_Pat	0.185**			0.152**
Int_Pat	0.134*			0.113^
I-Experience	**−0.015**			**−0.038**
UIC Involvement				
UIC_Paper		0.195***	0.173***	0.127**
UIC_Proj		0.115**	0.126**	0.075
UIC_Inst			0.203***	0.200***
Gender	0.148***	0.165***	0.130***	0.105**
Dep_Eng	0.036	0.035	−0.01	−0.018
N	323	323	323	322
Model (F)	8.796***	8.108**	9.443***	8.722***
Adjusted R^2	0.108	0.081	0.116	0.161

Significant level: *P < 0.1; **P < 0.05; ***P < 0.01; ^P < 0.15.

In the regression model tests, all models show significance and fit to explain personal academic performance. The adjusted *R*-squares are around 0.1∼0.4, and all F values show that the fitness tests of the models are all acceptable. The variables have no co-linearity problems, as all Variance Inflation Factor (VIF) values are lower than 2. The significant statistics show that personal technological capabilities, UIC involvement, and institutional factors have different impacts on academic research performance.

6.2 Technological capabilities bring positive impacts on academic performance

When examining the role of researchers' technological capabilities, we find that academic inventors' number of patents, especially patents in the domestic area, positively impacts their performance in academic research (Table 4). One possibility could be that academic researchers may gain different research ideas when they put forth efforts on developing specific technologies. The linkages between academic work and technological capabilities are significantly intensive and bring positive feedbacks for academia's work. As many previous findings showed (e.g. Van Looy et al. 2006; Meyer 2006a), researchers with a good performance in patent invention are also outstanding in their academic research work. Our research observes scholars in NTUST, an occupational-based S&T university, and shows a positive relationship. In an engineering-oriented university, researchers have experts to solve problems in technological

applications and transform them into relevant academic research. In an engineering-based university, outstanding senior academic researchers have a high preference to extend their accumulated technological capabilities toward better output in academic research work. There are naturally many different types of universities in Taiwan. Whether other types of universities, e.g. research-oriented universities that have relatively fewer experiences in accumulating technological resources, can also create high academic performance through this way remains to be explored.

6.3 Reinforcement or barrier: balancing between UIC activities and academic output

The models take academic performance as the dependent variable and show that UIC involvement acts as a positive driver for academic publications. In the joint works on paper publication (UIC_Paper), UI cooperation helps facilitate academic researchers to integrate their academic research work (Models 1b–d). UI cooperation in paper publication does not add to the pressure of facing different goals between UIC activities and academic research works. Cooperation in academic publications brings researchers different new ideas in personal academic studies. As Rosenberg (2002) found, the practical-oriented research helps researchers to create new ideas, particularly in the engineering field. If the ideas from industrial actors and market demand turn to cooperation in academic publications, then this makes researchers exhibit better personal performance in academic studies.

The effect of cooperation in UI contract research (UIC_Proj) in the model similarly shows positive and significant coefficients on academic research publications (Models 1b–d). Researchers spending efforts on a big UIC project always have an outstanding academic performance. In other words, new ideas for academic research can come from both academic cooperation and UIC joint projects. Between UIC activities and academic research output, academic researchers can take advantage of external resources. Researchers who are involved in a big UIC project tend to have cooperation with both industrial actors and academic researchers (Gulbrandsen and Smeby 2005). This also explains how they can also perform well in academic research. The existence of a mutual reinforcing relationship between UIC and academic research encourages researchers to balance these two types of work.

Personal high self-achievement characteristics could also be the reason to explain the above result. Academic researchers, who have a good reputation, are able to receive a high monetary value project. These researchers need to carry out the project to fulfill industrial demand and market challenges. Because of their high professional position recognized by society, these researchers have relatively high achievement motives to finish their duties. However, as Azagra-Caro et al. (2006) explained, some scholars do not participate in UIC out of the fear of losing academic freedom. Therefore, when facing different pressures between a UIC project and the requirement for academic research output, only specific senior and experienced researchers are able to balance their efforts and always finish both tasks with good performances.

6.4 Institutional factor brings resources *and* mitigates pressure

Academic researchers working in an environment with UIC involvement culture create high academic research performance. From Models 1c and 1d, we find that an institutional UIC cooperation culture (UIC_Inst) plays a very influential role on strengthening personal academic performance. Past findings showed that a scientist in a university is willing to share knowledge with external industrial actors when he/she is affiliated with a research center (Boardman and Ponomariov 2009). The research center/institution can provide organizational support and resources embedded in the institution. Academic researchers working in an environment where their colleagues can also cooperate with industrial actors with good performance also get the benefit of a positive impulse to conduct academic research work. One of the reasons can be the support of institutional UIC resources. Because such a department has accumulated different types of UIC social capital, the dual pressures from finishing both UIC work and academic research work for academic researchers can be mitigated during the process of being involved in different types of work. The other possibility can be that the pressure for reaching a UIC goal is negated by outstanding colleagues who are able to work well at UIC contract research. The UIC atmosphere within a department indeed helps researchers to balance the goals of different research tasks and to perform better in academic research publications.

6.5 External social capital strengthens the importance of UIC for academic output

Further examination aims to explore the moderating role of the diversity of external social capital. In Models 2a and 2b (Table 5), academic researchers are divided into two groups on the basis of their personal external linkages. The regression models show evidence that researchers belonging to different groups have different drivers on their academic work. The first difference can be found in the relationship between technological and academic publication performances. The positive relationship appears in the group with low diversified external linkages, but the technological capabilities do not positively relate to academic performance for those with diversified external links.

The second difference is the role a UIC research project plays on academic performance. Researchers who have diversified external linkages can utilize all types of UIC cooperation to strengthen their performance in academic research work. Conversely, researchers with few external linkages cannot increase their academic performance. The results may explain that researchers with few external linkages, probably junior researchers or pure scientists, can accumulate technological capabilities that induce good performance in academic research. For researchers with diversified external linkages, the capabilities to carry out UIC project research and communication capabilities have been embedded within the researchers. Hosting a high monetary value UIC project brings resources that help them to perform outstanding academic work. In other words, different personal backgrounds in connecting to an external social network explain how personal technological capabilities and UIC involvement may have different influences on academic research work.

The other moderating effect from cooperative partner types appears in Models 3a and 3b. Researchers who have UIC projects only from private sectors can utilize personal international patent output to create a better personal academic performance. In contrast, the other type of researchers who have UIC projects only from public sectors seems to take advantage of UIC involvement, including UIC paper and UIC scale, to strengthen academic performance. The results explain the differences in the purposes for conducting UIC

Table 5. The moderator of the diversity of external linkages

Dependent variable (Acade_Perf)	All sample	External linkage (Diversity)		External linkage (UIC partner)	
	Model 1d	Model 2a	Model 2b	Model 3a	Model 3b
	All	Low diversification (<2)	High diversification (>=2)	Projects only for **public** sector	Projects only for **private** sectors
Constant	–	–	–	–	–
Tech capability					
Dom_Pat	0.152**	0.176**	−0.022	0.080	0.156
Int_Pat	0.113^	0.130*	0.063	−0.042	0.357**
I_experience	**−0.038**	**−0.044**	**0.040**	−0.063	−0.077
UIC involvement					
UIC_Paper	0.127**	0.096*	0.353***	0.340***	0.108
UIC_Proj	0.075	0.057	0.197*	0.202**	−0.150
UIC_Inst	0.200***	0.136***	0.466***	0.407***	0.175*
Gender	0.105**	0.125**	−0.010	0.010	0.155
Dep_Eng	−0.018	0.029	−0.198*	0.046	0.062
N	322	261	61	96	82
Model (F)	8.722***	6.178***	5.054***	5.984***	5.154***
Adjusted R^2	0.161	0.137	0.351	0.296	0.291

Significant level: *P < 0.1; **P < 0.05; ***P < 0.01; ^P < 0.15.

from different cooperative partners. The industrial actors aim to have an outstanding position globally, and so international patents play a relatively important role. When some international patent office recognizes a scholar's technological applications, e.g. by approving patents, that scholar is further encouraged to improve personal academic work. Large-scale public UIC projects mostly focus on basic research, and so a UIC paper in a specific discipline strengthens a researcher's performance in academic studies.

In this study, we set up regression models to explore the scholar's academic performance, but the models still cannot show the causality that intertwines most of the variables. Although a positive relationship is shown, how a researcher can achieve high performance under both different types of research is still ambiguous. The results imply that personal technological capabilities and UIC involvement bring together positive forces for researchers in academic work. The institutional UIC culture is also a resource to strengthen researchers' performance. NTUST aims at providing professional education and fulfilling the demand from industries, and several recent policy incentives also encourage researchers to strengthen their academic work. This means that the research faculties at the university now offer different types of resources. Aside from technological capabilities in patents, researchers also bring external social capital that helps them discover new ideas in academic research. The close relationship among personal technological capabilities, UIC experiences, and academic work implies that researchers can reach high performances in different fields through different ways. They need to consider greater personal research preferences and capabilities. With the existence of different backgrounds, researchers can extend their different advantages, which should help them to employ different methods to balance different task requirements.

7. Conclusion

This study has provided evidence of several relationships between academic publications and UIC. First, we show that academic researchers' technological capabilities are the key factor to facilitate their academic performance. Researchers' efforts on technological development can also be a positive force to strengthen their academic work. Second, a researcher's U-I joint work in academic publication has a positive impact on personal academic performance. Furthermore, UI cooperation in practical projects brings positive impacts for specific researchers, i.e. researchers with diversified external social capital. A mutual reinforcement exists between UIC activities and academic work, but academic researchers have different preferences and personalities when balancing between UIC and academic research. Researchers still have to decide whether they should start from diffusing academic findings in order to fulfill industrial demand or establishing external industrial resources for academic work.

Third, the institutional culture that has accumulated lots of interactions with industrial actors (UIC atmosphere) can help provide abundant resources for all academic faculties. As an institutional UIC culture accumulates a reputation to connect with industrial actors, researchers are able to balance between academic work and UI cooperation since the institution has become a supportive force for UIC activities during project research. Fourth, turning to moderator effects, compared to the group with diversified external social capital, researchers without diversified external links can utilize their technological capabilities to increase academic work. In addition, the type of cooperative partners for a UIC project also explains the differences in a researcher's academic performance. Researchers working on private UIC projects can utilize international technological recognition in patent offices to strengthen personal academic publications. The other type of researchers focusing on public UIC projects need to accumulate resource learning from large-scale and basic research in joint UIC publications to facilitate personal academic research work.

In the process of analyzing the empirical data, this study has several limitations that need to be worked on further. The first limitation is the data set used in our analysis. We focus on one case, NTUST, and so the results may only be suitable to explain scholars at an engineering-oriented university. Although this is a special case for researchers to explore the difficulties between technological research and academic research, we still have to stress the importance

on observing the phenomena at different types of universities. A future extension can look at comparing the differences between S&T universities and general research-oriented universities. The second issue, also related to the data set, is the measurement in variables. We have some limitations on data identification, e.g. the discipline of UIC projects worked on by researchers or the interaction modes of UIC projects, as well as a broad dimension in measuring personal technological capabilities. The interaction mode or research discipline can be an influential factor to explain a researcher's academic research work, whereas patent output may play a less important role in some academic fields.

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