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How University Departments respond to the Rise of Academic Entrepreneurship? The Pasteur's Quadrant Explanation

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Abstract:
This paper examines how universities can develop a new organizational structure to cope with the rise of academic entrepreneurship. By deploying the Pasteurian quadrant framework, knowledge creation and knowledge utilization in universities are measured. The relationships between university antecedents, Pasteurian orientation, and research performance are analyzed. A survey of university administrators and faculty members collected 634 responses from faculty members in 99 departments among 6 universities. The findings indicate that university antecedents of strategic flexibility and balancing commitment contribute to a greater Pasteurian orientation in university departments. The higher degree of Pasteurian orientation has significantly positive impacts on the performance both of knowledge creation and knowledge utilization. Moreover, the Pasteurian orientation acts as a mediator between university antecedents and research performance. Using cluster analysis, the departments are categorized into four groups. The differences between university- and department- factors in these four groups are

examined and discussed. We conclude that not all university departments should move toward the Pasteurian group, and there are specific organizational and disciplinary factors resulting in mobility barriers among groups. Policies to encourage academic entrepreneurship should consider these mobility barriers, along with this new governance of science.

Keywords: Academic entrepreneurship, Pasteur's quadrant, research excellence, research commercialization

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1. Introduction

The increased commercialization and entrepreneurship of academia in the past few decades has stimulated investigation in the fields of science governance (Merton, 1968; Dasgupta and David, 1994; Stokes, 1997), university-industry linkage (Stankiewicz, 1986; Geisler and Rubenstein, 1989; D'Este and Patel, 2007), the triple helix model (Leydesdorff and Etzkowitz, 1996), and academic entrepreneurship (Etzkowitz, 2003; Shane, 2004a). Along with reforms in S&T policy and economic transformation, universities have developed a third mission, that of providing a fundamental economic contribution to society (Etzkowitz et al., 1998; Molas-Gallart, 2004). The above studies have shown that universities have great potential for contributing to economic and social development. The rise of academic entrepreneurship has enforced universities to adjust their policies, structure and resource allocation in order to maintaining their original goals along with this new mission (Shane, 2004b; Powers and McDougall, 2005).

Entrepreneurial activities in universities involve the process that enables the research outcomes from laboratories to be disclosed, to demonstrate their originality and utility, and then be channeled into marketplaces. The common approaches to technology commercialization employ patenting, licensing, and spin-off venturing. Prior studies have argued that governmental policies and regulations influence the institutional context of entrepreneurial universities in aspects such as their mission, structure, resource allocation, and performance evaluation (Mowery et al., 2001; Etzkowitz, 2003; Whitley, 2003; Chreim et al., 2007; Jain et al., 2009). Moreover, some scholars have suggested that organizational context of these universities, including the norms, peer pressure, behavior of reference group, and specific agencies, may strongly influence faculty members' behavior (Bercovitz and Feldman, 2008; Jain et al., 2009; Haas and Park, 2010). Furthermore, as faculty members advance through their academic career (Dietz and Bozeman, 2005), industrial experience (Ambos et al., 2008), and resource availability (D'Este and Perkmann, 2010) are found to influence their engagement in entrepreneurial activities.

However, little research has been undertaken to deal with tensions of the achievement of knowledge creation and knowledge utilization that are faced by universities. How can universities develop contextual antecedents to foster organizations and faculty towards academic entrepreneurship? What departments and disciplinary fields develop better performance of research outcomes than others, and why do they do so? This paper uses the notion of the Pasteurian Orientation (PO) and argues the PO is appropriate to explain responses to the rise of academic entrepreneurship. Specifically, entrepreneurial universities need to pursue knowledge creation and knowledge utilization simultaneously. Specifically, the PO can be sustained through organizational support and faculties' engagement. The PO acts as a mediator between university antecedents and research performance.

This paper is organized as follows. The significance and tension of developing academic entrepreneurship is illustrated in Section 2.1. The relationship between entrepreneurial universities and the PO is discussed in Section 2.2, and two types of knowledge orientations combined to support the existence of PO are introduced. The contextual antecedents of universities in supporting the PO are developed in Sections 2.3. Factors that stimulate the PO and its impacts on research/commercial

performance are proposed in Section 2.4. The framework of university antecedents, PO, and research/commercial performance are discussed in Section 2.5. The data collection, data analysis and definition of variables are detailed in Section 3. The descriptive statistics, correlations and recursive regression models are shown in Section 4. The similarities and differences of these research results compared to previous studies are discussed in Section 5. Finally, in the concluding section conclusions and implications are made.

2. Theoretical Model

2.1 The rise of academic entrepreneurship

From the postwar to period up to the 1980's, universities focused on basic research, thereby contributing to public knowledge creation (Stokes, 1997). Since then, the role of universities in the knowledge–based economy has been considered more important. Specifically, the process and nature of knowledge generation has changed from "Mode 1" to "Mode 2" (Gibbons et al., 1994). And there are radical changes that influence the role of universities. From the government, financial support has been reduced by constraints on public expenditures. With industry, firms face the strong competitions in technology development, and stress connecting themselves with long-term research and directing basic research to cultivate their core competencies. To help resolve these problems, many stakeholders promote the universities need to be integrated into the system of innovation. This can benefit universities by helping them to obtain funding from new sources and to contribute more to society. Industries build a collaborative relationship with universities in order to obtain advanced technologies and to develop their own technology capabilities, as well as retaining their human resource (Martin, 2003).

Two specific theoretical approaches are related to the rise of academic entrepreneurship. First, the new governance of science approach argues that academic research not only contributes to knowledge creation but also supports the developments of the knowledge application with economic benefits (e.g. Merton 1968; Dasgupta and David, 1994; Stokes, 1997; Mckelvey, 1997; Nelson, 2004). The faculty members leverage the academic research results through creating start-ups, and also speed up innovation in the region. Second, in entrepreneurial university approach emphasizes that universities must play a positive role within the knowledge base through intellectual property right (IPR) management mechanisms, such as technology transfer, contract research, patent licensing, and academic spin-off (Etzkowitz, 2003; Shane, 2004a). Moreover, Etzkowitz (2003) argues that entrepreneurial universities could generate and translate the knowledge to fulfill economic and social needs directly. Universities are required to play an important role in the triple-helix approach to enforce the innovation in the specific region because they have an advantage in gathering and accumulating the necessary talent, knowledge, and resource (e.g. Leydesdorff and Etzkowitz, 1996; Etzkowitz, 1998; Etzkowitz and Leydesdorff, 2000).

This paper argues that universities should respond to the transforming paradigm by stressing the dual importance of research publication and research commercialization. The rise of university entrepreneurial activities stimulates faculty members to realize the potential value of research outcomes. Universities and their subordinate departments are undergoing the second revolution not just for the purpose of knowledge creation, but also to respond to social and economic development in the knowledge-based economy (Etzkowitz, 1998; 2003). The transformation of

entrepreneurial universities gradually alters the scientific commons to fit the policy and regulation in accordance with the governance of science, and adjusts the relationships with the external stakeholders as well.

2.2 Entrepreneurial Universities and Pasteur's quadrant

In the period after World War II, research work divided into two streams to avoid the privatization of knowledge generation and to maintain academic research outcomes as a part of the public good. Bush (1950) verifies that the research attributes can be categorized into basic and applied research. Manual (1970) proposes a dichotomy from pure basic research to experimental development on one dimensional linear spectrum which connects knowledge enhancement and technological innovation (Stokes, 1997; Beesley, 2003; Goldfarb, 2008). Normally, governments fund academic research projects specifically focused on the understanding of nature and society. In contrast, private firms mainly invest in technology development and deploy the resulting innovations in the marketplace as soon practical (Goldfarb, 2008; Mendoza, 2009).

Since the 1980's, some governments have considered the traditional viewpoint of dividing research streams into a spectrum ranging from basic to applied, especially due to the ambiguous boundary between these two in several cases. Stokes (1997) cites as an example the research of Louis Pasteur that developed a theoretical understanding of microbiologic processes, and in practice led to the control of food spoilage and microbial-based disease (Mendoza, 2009). Specifically, he proposes a matrix of consideration of utility and fundamental understanding as a basis to evaluate strategic research (Beesley, 2003). Etzkowitz (2003) argues that research has transformed gradually to interact between the basic and applied researches, and move from fundamental understanding to utilization. Complying with the transformation in academic institutions, this study revises these two axes by adapting the following two perspectives. One perspective is knowledge creation, which means enhancing the understanding of universal knowledge frontier of human beings. The other is knowledge utilization, which means resolving specific technical or social problem and realizing the market potential of innovation (See Figure 1).

Specifically, the upper left cell, referred to as the Bohr's quadrant, focuses on basic research with little consideration of practical application, such as in astrophysics. The lower-right cell, called as the Edison's quadrant, concentrates on research directed towards technology development, which seeks more efficient knowledge utilization. Moreover, Stokes (1997) proposes the concept of Pasteur's quadrant, which focuses on the basic research inspired by understanding and using. He argues that the Pasteur's quadrant is in a better position because the user-inspired basic research could move flexibly to the Bohr's quadrant to increase conceptual understanding or to the Edison's quadrant for more practical applications, and the interactions between two perspectives can yield a unique and dynamic model for strategic research. Finally, for the lower-left quadrant, Stokes (1997) argues that there is research that contains neither the creation nor the use of knowledge, but instead systematically explores particular phenomena, for example as bird watching or history. He cites Peterson, the well-known author of bird-watching guides, as example but does not give this cell a name. Moreover, Reeves (2006) suggests that research in this quadrant targets the instrumental and educational developments that are preliminary to the activities in Bohr's and Edison's quadrants. This current paper uses Socrates as an example for the lower-left cell since he sought to develop a methodology to systematize contemporary

knowledge, distribute ancient knowledge, and educate the people to influence the future use of knowledge.

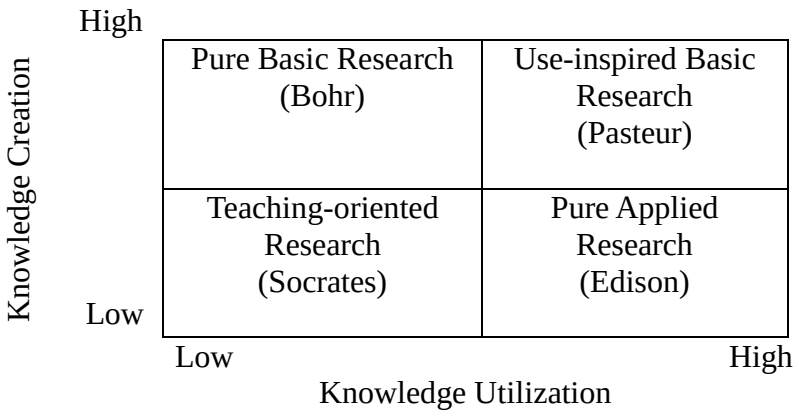

Figure 1 Quadrant Model of Scientific Research
Source: Adapted from stokes (1997)

This paper argues that the Pasteurian orientation (PO) of universities can be described as the capacity of disciplinary departments to comply with organizational goals, strategies, and structure in order to achieve knowledge creation and knowledge utilization. Based on Stokes' framework of scientific research, this study argues that entrepreneurial universities can pursue a dual-track effort toward Pasteur's quadrant. Prior research suggests that organizational support, such as resource inputs, capabilities training, incentive mechanisms are critical to stimulate faculties' involvements (Bercovitz et al., 2001; Etzkowitz, 2003; Geuna and Muscio, 2009; D'Este and Perkmann, 2010). Faculty engagement can be influenced by the organization and individual's capabilities, resource availability, career planning, and commitment (Owen-Smith and Powell, 2003; Bercovitz and Feldman, 2008; Jain et al., 2009; D'Este and Perkmann, 2010). This paper further proposes a conceptual model of PO (Figure 2). Specifically, PO includes both orientations: knowledge creation and knowledge utilization. Each orientation needs to be maintained through organizational support and faculty engagement. Specifically, the knowledge creation orientation describes the capacity to pursue pure basic research (i.e. Bohr quadrant), while knowledge utilization orientation describes the capacity to pursue pure applied research (i.e. Edison quadrant). Maintaining high PO enables a university to persuade its departments to not only contribute to knowledge creation, but also engage in its utilization (i.e. Pasteur quadrant).

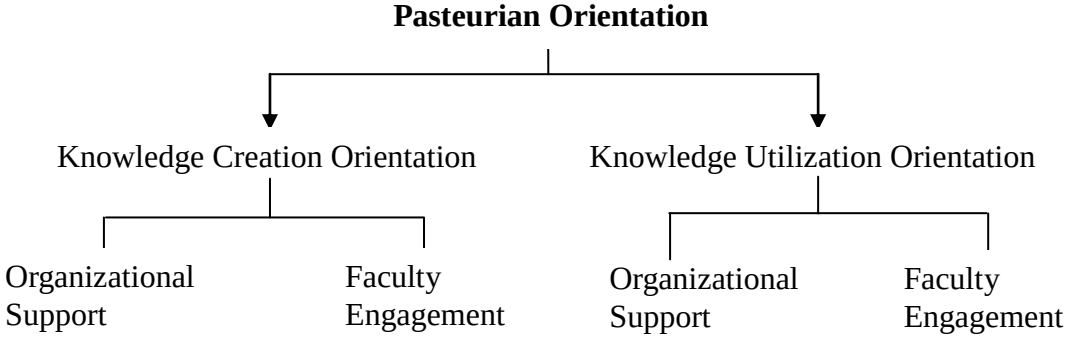

Figure 2 Decomposition of Pasteurian Orientation

2.3 University-level facilitators for the Pasteurian orientation of departments

In the past few decades, universities have acted as the most important source of knowledge foundation in the innovation system (Nelson, 2004). The institutional contexts of academic institutions influence arrangements such as the funding sources. For example, many governments have redefined their policies to encourage universities to be more entrepreneurial, and have enacted legislative reforms to deregulate the limitations and encourage the openness of universities to this direction. In the studies of Mowery et al. (2001) and Shane (2004b), they argue that the *Bayh–Dole Act* provides an effective incentive to the patenting activities of U.S. universities, and even promotes an increase in start-up activity. The *Act* is further discussed not only stimulated the commercialization of academic inventions, but also accelerated the involvement of technology commercialization at universities (Grimaldi et al., 2011).

Moreover, in the current organizational contexts, universities are adjusting their infrastructure, strategy, and attitudes toward several new organizations by establishing technology transfer offices, patent offices, technology liaison offices, and university-affiliated incubators to support the commercialization and entrepreneurship (Stankiewicz, 1986; Mowery et al., 2001; Etzkowitz, 2003). Additionally, many universities have established internal entrepreneurial funds, invested in academic spin-offs, and redefined the criteria for evaluating faculty members' performance (Beesley, 2003; Geuna and Muscio, 2009). These dual-goal contexts enable universities to better meet the multiple missions and manage the tensions between the research and commercial need (Ambos et al., 2008; Chang et al., 2009). This study argues that the organizational contexts of academic entrepreneurship encourage the university departments to move toward increased Pasteurian orientation.

The evolving institutional and organizational contexts reflect the needs for strategic adjustments in universities, and a great deal of organizational reconstructions is intended to provide *strategic flexibility* for universities. On the one hand, university departments are transforming the knowledge utilization orientation and building up economic sensitivity of scientific outcomes derived from research projects. On the other hand, university departments are developing the knowledge creation orientation and maintaining academic routines to execute research projects and to disseminate the research findings.

Since academic routines are evolving and available internal resources are usually limited, resource allocation for the activities in universities is critical and influential. Academic researchers undertake research initiatives not only to satisfy their own scientific curiosity, but also to comply with resource availability at the various organizational levels. Swamidass and Vulasa (2009) suggest that asymmetric information between academic inventors and IPR management staffs challenge the willingness to disclose inventions. Previous studies have verified that academic scientists who have industrial contacts increase their research capabilities beyond what would be allowed by the core academic funding (Etzkowitz, 2003; Shane, 2004a). Universities are suggested to hire researchers who are willing to work across the boundary of technological applications (Geuna and Nesta, 2006).

Moreover, many universities provide supplementary funding to support university-industry (U-I) collaborative research, therefore enlarging funding sources and stimulating technology transfers. Prior studies have argued that the reward system in universities is critical to facilitate the disciplinary departments and faculty members committed to fulfill the dual roles (Beesley, 2003; Whitley, 2003; Geuna and Muscio,

2009). The performance evaluations and the reward systems should be re-designed, so that paper publication, patent grant, U-I project, and industrial services are included in faculty promotion review. These evaluation criteria do not just concern the performance of research excellence to society but also stress the performance of research contribution to industry. This study argues that the commitments of research projects themselves and research outcome utilization together encourage academic departments to seek a balance between knowledge creation and knowledge utilization. Thus:

Hypothesis 1：The university antecedents with higher strategic flexibility and balancing commitment, the higher level of Pasteurian orientation of departments is.

2.4 Pasteurian orientation and overall research performance in university departments

The current academic paradigm stresses both scientific and economic contributions. Professional norms and organizational identities are shaped by the attitudes and behavior of reference groups that influence individual researchers' behavior (Bercovitz and Feldman, 2008; Jain et al., 2009; Haas and Park, 2010). Conceptually, university departments display the centralization of control over the goals, resources, and careers within and between the universities and similar organization (Whitley, 2003; Searle, 2006). Universities creating structural and contextual mechanisms for the disciplinary departments to manage research activities are found to be differentiated and complementary (Chang et al., 2009).

In addition, the individual engagement is also an important stimulant to the involvement of knowledge creation and knowledge utilization. Searle (2006) argues that the beliefs of professors about research commercialization and their proper role in third mission would influence the entire decision-making processing. Moreover, at the different academic career stages (Dietz and Bozeman, 2005), the available experience and the resources (Ambos et al., 2008; D'Este and Perkmann, 2010) would influence individual's engagement. Jain et al. (2009) also suggest that the networks faculty can access are important incentives to engage in commercialization. This current study argues that the co-existence of organizational support and individual engagement would enhance the level of PO and the subsequent performance in knowledge creation orientation and knowledge utilization. Thus:

Hypothesis 2：The higher level of Pasteurian orientation in a university department, the higher of department's research/commercial performance is.

H2a: The higher coexistence of organizational support and faculty engagement for knowledge creation orientation, the higher research publication of the departments is.

H2b: The higher coexistence of organizational support and faculty engagement for knowledge utilization orientation, the higher research commercialization performance of the departments is.

Moreover, Stokes (1997) argues that research activities in Pasteur's quadrant could

enhance research performance because of considerations for knowledge creation and knowledge utilization. And the majority of existing research has shown a positive relationship between academic research outcomes and the likelihood of the involvement with commercial activities for the researchers (Di Gregorio and Shane, 2003; Owen-Smith and Powell, 2003; Van Looy et al., 2006). Thus, we propose the following hypothesis.

H2c: The higher level of Pasteurian orientation in a university department context, the higher research performance the university departments will be.

2.5 Mediation Effects of Pasteurian orientation

Prior studies argue that the mediating effect of the contextual duality occurs because the antecedents themselves can create and amplify internal tensions, and even contribute to the simultaneous capabilities for knowledge creation and knowledge utilization (Ambos et al., 2008). In this current study, we argue that the university's antecedents create a top-down context. Specifically, strategic flexibility creates the legitimized infrastructure, guidelines, and function, and provides a clearly defined role of stakeholders who are involved in research publication and research commercialization. Moreover, balancing commitments creates multiple choices for university missions, which thereby encourages university departments to juggle their resource inputs and development orientation between knowledge creation and knowledge utilization.

Moreover, this study suggests that PO, comprised by organizational support and faculties' engagement in knowledge creation and utilization, would eventually influence the overall research performance. More importantly, PO creates a bottom-up context that enables faculty members to determine their choice of career portfolio. This study argues that PO mediates the relationship between the two university antecedents and departments' research performance. That is, the two contextual antecedents influence the research performance through the capacity of PO in university departments. Thus:

Hypothesis 3：Pasteurian orientation mediates the relationship between context—as captured by the interaction of strategic flexibility and balancing commitment — and the department's overall research performance.

This study depicts the research framework and the corresponding hypotheses in Figure 3. Specifically, superior research performance in paper publication and research commercialization is expected to be achieved by building the antecedents of strategic flexibility and balancing commitment that collectively define university contexts and allow the meta-capabilities of knowledge creation and knowledge utilization to flourish simultaneously.

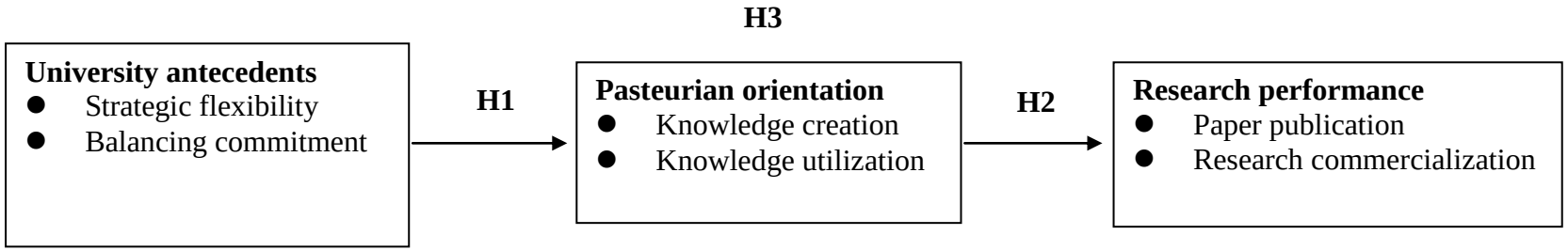

Figure 3 Research Framework: Antecedents, Pasteurian Orientation and Performance

3. Methods

3.1 Questionnaire development

3.1.1 Item development

As suggested by Gibson and Birkinshaw (2004), this study collects data by asking a large sample of individuals to rate their universities and departments on the contextual antecedents and the PO capacity, and then aggregate the measurements to create department-level measures. Because no existing measure assesses university antecedents and PO capacity, we developed a survey after referring to items identified by Ghoshal and Bartlett (1994) and Chang et al. (2009). The initial questionnaire, written in English, was translated into Chinese and then back-translated into English. A cover letter attached with the questionnaire explained the research purpose and provides assurances of anonymity and confidentiality.

3.1.2 Judgment analysis

We recruited 15 faculty members and doctoral students as subject experts to judge the content of the draft questionnaire. In addition, we held three focus groups to discuss these questions. The percentage of correct assignment was calculated for each item by considering items with 60% or higher as correct classification. Based on descriptions and interviews, 40 questions were chosen for the questionnaire. Among those, there were 15 questions assessed for university antecedents, 17 questions for the development in PO, and 8 questions for performance.

The items of university antecedents and PO capacity used a 7-point Likert-scale in the survey. To mitigate the problem of common method bias, this study used different levels of respondents for the independent variables (university's antecedents) and the dependent variables (Pasteurian orientation and performance). Specifically, the administrators were merely responsible for the items of university's antecedents, while the non-administrative faculty members answered the items regarding Pasteurian orientation and performance. That is, for the independent variables we aggregate only those respondents who identified themselves as administrators; for the dependent variables, only those respondents who identify themselves as non-administrative faculty members.

3.2 Participants

The survey items were initially tested in a pilot study conducted with 110 faculty members. Exploratory factor analyses of the data from the pilot study indicated that the meaning of the survey items was clear. Prior research argued that the goal of theoretical sampling is to choose research targets which are likely to replicate or extend existing theory (Eisenhardt, 1989). The sampling criteria of this current study focused on university departments of science, engineering, and medical research since they have higher potential to commercialize their research results.

This study tabulated the number of patents granted to faculty members in the Taiwanese universities between 2000 and 2010 from the patent databases of the domestic IPR authority, USPTO, and EU patent office. In order to represent the differentiated attributes of organizational context and comply with the Pasteurian quadrant, six universities are chosen to represent the attributes of state-owned (e.g. university A, B, and C), private (e.g. university E), S&T university (e.g. university F), and medical college (e.g. university D) respectively. Moreover, university A and B are generally highly considered both in terms of their research publication and their research commercialization. University C and D are generally highly regarded for their research publication, but with low research commercialization. University E is less well considered for both its research publications and research commercialization.

University F is considered to have less low research publication and greater research commercialization. Finally, the original list of 29 schools and 172 departments within these universities was collected from their websites.

After checking with the researcher database in the National Science Counsel to ensure the consistency of survey targets, the total number of the respondents is 2,868 faculty members. This study also compared respondents to non-respondents in terms of number of published papers and patent grants and found no statistically significant differences at the $p < 0.10$ level. We obtained 711 valid questionnaires (a 26% response rate). To meet the analysis criteria, we required a valid department to have at least one administrator and four faculty members. Thus 77 surveys were dropped because they did not match the criteria of a valid department. Finally, there were 634 valid questionnaires, representing 27 schools and 99 departments (58% of the population).

Respondents who have completed the survey data are consist of 157 administrators and 477 non-administrative faculty members. The administrators served as deans/directors/chairs in the administrative offices, disciplinary schools, departments, or institutes in each university. There are 368 male respondents (83% of the respondents). There are 342 full professors (54%), 139 associate professors (22%), and 133 assistant professors (21%). The average tenure for the respondents is 13.6 years in academic works. Moreover, there are 393 respondents (62%) who had already received tenure as faculty members. Table 1 provides a brief breakdown of the sample.

Table 1 Characteristics of the Sample Universities

University	Ownership	Type	No. of schools	No. of departments	Total respondents	Nonexecutive	Executive
A	Public	General	8	42	256	214	42
B	Public	General	5	19	114	84	30
C	Public	General	5	9	66	46	20
D	Public	Medical	4	9	63	41	22
E	Private	General	3	12	81	62	19
F	Private	Science & Technology	2	8	54	30	24
Total			27	99	634	477	157

3.3 Measures

3.3.1 Research performance

To better reflect the qualitative and quantitative attributes of research performance, this study employs subjective and objective approaches to investigate the departments. The subjective research performance is measured by obtaining faculty members' responses to performance indices assessed with a 7-point Likert type scale. The survey asks faculty members to 'assess your department/institute's performance OVER THE PAST THREE YEARS relative to other equivalent departments.' The performance indices include research publication and research commercialization. For this, there are five items condensed to one factor including: (1) "My department has achieved high research excellence;" (2) "My department has achieved high research commercialization;" (3) "My department has achieved high performance in both research and commercialization;" (4) "The faculty members encouraged by incentives of my department have high job performance;" and (5) "The overall performance of my department is high". The five items load on a single factor having an eigenvalue of 2.38 ($\alpha = .86$). We refer to this factor as *Subjective Performance*. To evaluate objective approach, this study asked the respondents about their research publications (i.e. journal papers published in the databases of SCI, SSCI, and EI) and research commercialization (i.e. patent grants, technology transfers, and university-industry

collaborative projects) over the past three years. This factor is referred to as *Objective Performance*. These relative measures of *Objective Performance* were highly correlated with the aggregated measures of *Subjective Performance*, as rated by administrators (r = .75, p < .05), indicating strong external validity for the subjective performance measure. Moreover, as suggested by Gibson and Birkinshaw (2004), we created an interaction term (i.e. overall performance) using the multiplicative interaction of the research publication variable and research commercialization variable.

3.3.2 Pasteurian orientation

We conceptualize PO as two dimensional constructs comprised of knowledge creation orientation and knowledge utilization orientation. We measure knowledge creation by asking faculty members to indicate the degree to which they agree with the following four statements: (1) "The research facilities and environments in my department/institute are excellent;" (2) "Awards for research excellence are emphasized highly in my working department/institute;" (3) My supervisor(s) and I have reached a consensus in pursuing research excellence;" and (4) "My colleagues and I have reached a consensus in pursuing research excellence". The four items load on a single factor having an eigenvalue of 2.71 (α = .82). We renamed the factor as *Research Support*. Additionally, there are three items condensed to a single factor including: (5) "My research topics cover both incremental and radical breakthroughs;" (6) "The activities of research publication occupy much of my working time;" and (7) "I have considered both personal interests and environmental demands to conduct my research agenda". These three items load on a single factor having an eigenvalue of 1.81 (α = .72). We renamed this factor as *Research Engagement*. Specifically, the two factors account for 65 percent of the variance. Moreover, we compute the multiplicative interaction between *Research Support* and *Research Engagement*, reflecting research publication as the *Knowledge Creation Orientation* in universities.

We also measure knowledge utilization by asking faculty members to indicate the degree to which they agree with the following: (1) "The guidance and incentive for industrial collaborative research are superior in my university;" (2) "The guidance and incentives for technology transfer are superior in my university;" (3) "The guidance and incentives for IPR application are superior in my university;" and (4) "The guidance and incentive for creating spin-off are superior in my university". These four items load on a single factor having an eigenvalue of 3.69 (α = .95). We renamed the factor *Commercialization Support*. Additionally, there are four items condensed to one factor including: (5) "The activities of research exploitation occupy much of my working time;" (6) "I have participated the course related to patent application, protection, or technology transfer;" (7) "I have engaged in both incremental and radical research innovation;" and (8) "I have considered both personal interests and environmental demands in exploiting the results of my research". These four items load on a single factor having an eigenvalue of 2.87 (α = .89). We renamed this factor as *Commercialization Engagement*. Specifically, the two factors account for 82 percent of the variance. Moreover, we computed the multiplicative interaction between *Commercialization Support* and *Commercialization Engagement*, reflecting our argument that research exploitation as *Knowledge Utilization Orientation* in universities. Finally, we computed the multiplicative interaction between *Structural Research*, *Contextual Research*, *Structural Commercialization*, and *Contextual Commercialization*, reflecting that knowledge creation orientation and knowledge utilization orientation are non-substitutable and interdependent.

3.3.3 University antecedents

This study measures university antecedents using 11-item scales to represent the dimensions of strategic flexibility and balancing commitment as identified by Chang et al. (2009). Factor

analysis identifies these items as clustering together as three factors. One of the factors represents a combination of the items developed for the antecedent, strategic flexibility. The other two factors represent specific combinations of the items regarding balancing commitment in forms of research work and commercialization work.

Specifically, the administrative respondents indicate that the following items encourage people at their level: (1)"My university often sets up cross-departmental committees to respond to ongoing external opportunities;" (2)"My university often sets up cross-departmental committees to reconfigure inappropriate regulations;" (3)"The management mechanism of my university can rapidly respond and adjust the priorities of organizational goals;" (4)"My university often sets up temporary mission-oriented committees to integrate resource allocation and reconcile potential conflicts;" and (5)"My university has established a new unit/institution to integrate resource allocation and reconcile potential conflict". These five items load on a single factor having an eigenvalue of 3.23 and accounting for 52 percent of the variance (α = .88). Thus, we retained the name of this factor as *Strategic Flexibility*.

Moreover, the administrative respondents indicate the following items encourage people at their level: (1) "The major goal of my university is to achieve research commercialization;" (2) "My university has engaged in substantial resources to realize the potential of research outcomes;" and (3) "My university has performed long-term support regarding research exploitation". These three items load on a single factor having an eigenvalue of 6.96 (α = .95), and reflect the dimension of resource commitment. The executive respondents also indicate the following items encourage people at their level: (1) "My university has engaged in substantial resources to pursue research excellence;" (2) "The major goal of my university is to achieve research publication;" and (3) "My university has performed long-term support regarding research publication". These three items load on a single factor having an eigenvalue of 8.40 (α = .85), and reflect the dimension of balancing commitment. Finally, we referred to this term as *Balancing Commitment*.

3.3.4 Control variables

This study employed three control variables to reflect the characteristics of the departments. First, the number of faculty in each department, count as 'department size' obtained from the 2,868 survey respondents (e.g. Lach and Schankerman, 2008; D'Este and Perkmann, 2010). Then, we used the macro-variables to represent the research attribute of the departments. First, 'College' is a dummy variable that denotes the college that each department belongs to, specifically 1 for colleges with higher commercial potential, including Engineering, Life science, and Medical. In addition, we create the dummy variables to represent the research fields if the departments belong to Engineering, Life Science, or Medical disciplines (e.g. Ambos et al., 2008; D'Este and Perkmann, 2010).

3.4 Aggregation

Each of the variables in our model is meant to represent department characteristics, as we utilized individuals as raters of those characteristics. In the terms of multilevel theory (Klein and Koslowski, 2000), this study consists entirely of "shared unit-level constructs," meaning that we gather data from individuals to assess unit-level characteristics. Conceptually, this makes sense, given that individual faculty members are most familiar with the extent to which their department exhibits certain attributes of university antecedents, as well as Pasteurian orientation and research performance. Yet it is critical with such aggregated variables to statistically demonstrate within-unit agreement and between-units differences (Ancona and Caldwell, 1992; Klein and Koslowski, 2000).

We calculated an interpreter agreement score (r_{wg}) for each variable, which ranges from 0

("no agreement") to 1 ("complete agreement") (James et al., 1993). Glick (1985) suggests .60 as the cutoff for acceptable interrater agreement values. The median inter-rater agreements are .88 for performance, .86 for Structural Research, .74 for Structural Commercialization, .89 for Contextual Research, and .90 for Contextual Commercialization, indicating adequate agreement for aggregation. We also generated two intraclass correlation coefficients, ICC(1) and ICC(2), using one-way analysis of variance (ANOVA) on the individual-level data, with unit as the independent variable and the scale scores as the dependent variables.

Kenny and LaVoie (1985) suggest that an indication of convergence within units is an ICC(1) value greater than zero with a corresponding significant ANOVA test statistic (F). In all the departments, the ICC(1) is greater than .19 and the F is significant (Bliese, 2000). For the ICC(2) values, the valuable indicators for the reliability of the unit mean, are .54 for all departments, which indicate that the means for the sets of perceptions for each variable are accurate representations of the true score for the unit (James, 1982).

3.5 Validity checks

The discriminant validity is established through exploratory and confirmatory factor analysis to verify our constructs using all items from all of the scales. The exploratory factor analysis replicates the intended three-factor structure (i.e. university antecedent, Pasteurian orientation, and research performance) to be used in tests of hypotheses. Items load on the intended factors, all of which have eigenvalues greater than one. Moreover, the analysis does not reveal a single or general factor that would suggest the presence of common method (Brewer et al., 1970) or social desirability variance (Thomas and Kilmann, 1975).

This study conducts confirmatory factory analysis to verify the proposed three-factor model to an alternative seven-factor structure (e.g. strategic flexibility, resource commitment, structural research, contextual research, structural commercialization, contextual commercialization, and performance) is tested by using confirmatory factor analysis. The overall chi-square test of model fit is statistically significant (χ^2 (413) = 939.4, χ^2/df = 2.27, p < .001). The Root Mean Square Error of Approximation (RMESA) is .08 and the standardized RMR is .07. The Normed Fit Index (NFI) is .84, Non-Normed Fit Index (NNFI) is .89, the Comparative Fit Index (CFI) is .90, and the Goodness of Fit Index (GFI) is .75. The statistical significance of each estimated parameter is also assessed by respective t-values, which are found to be significant (p < .05). The completely standardized solution indicates that the convergent validity of all measures is acceptable (Bagozzi et al., 1991). The commonalities of the variables are well above 0.50, and the construct reliabilities for the factors are also high. Taken together, these results suggest that the concept of the three scales is not only theoretically, but also empirically distinguishable.

4. Results

4.1 Tests of Hypotheses

Descriptive statistics (means, standard deviations, and correlations) for all the variables are presented in Table 2. The variables of knowledge creation orientation, knowledge utilization orientation, and their interaction with Pasteurian orientation are significantly and positively correlated with the performance variables. Furthermore, there is a strong, positive correlation between knowledge creation orientation and knowledge utilization orientation, showing that departments can indeed achieve both simultaneously. The strong correlations indicate the importance of the dual capacity. The contexts of Strategic flexibility and Balancing commitment, and their interaction (i.e. university antecedents) are significantly and positively related to the performance variables. As stated earlier that the variables of university antecedents and the performance variables are rated by different respondents, these positive

correlations are worthy of attention. More importantly, the findings prove evidence that university antecedents are related to performance. However, our subsequent analysis below verifies the complexity of this relationship as mediated by Pasteurian orientation.

This study tests the hypotheses using ordinary least square (OLS) regression. Hypothesis 1 predicts that strategic flexibility and balancing commitment would enhance the level of Pasteurian orientation. In the Model 1, University antecedents, the multiplicative interaction of strategic adjustment and balancing commitment is found to positive and statistically significant related to Pasteurian orientation ($\beta = .191$, $p < .05$). As shown in Model 2, the relationship between strategic flexibility and Pasteurian orientation are positive but not statistically significant ($\beta = .107$). However, in Model 3, balancing commitment and Pasteurian orientation are positive and statistically significantly ($\beta = .204$, $p < .05$). Overall, this study verifies that Hypothesis 1 is supported.

Hypothesis 2 predicts that Pasteurian orientation, the multiplicative interaction of knowledge creation orientation and knowledge utilization orientation, will be positively related to research performance. As depicted in Table 3, Model 4 and Model 5 measure separately the relationship of knowledge creation orientation and knowledge utilization orientation to research performance ($\beta = .511$, $p < .001$, $\beta = .321$, $p < .001$); then the coefficient for Pasteurian orientation in model 6 is positive and statistically significant ($\beta = .226$, $p < .05$). The results of H2a, H2b, and H2c strongly support Hypothesis 2.

Hypothesis 3 predicts that Pasteurian orientation will mediate the relationship between university antecedents and performance. Analyzing mediation involves three steps (Baron and Kenny, 1986; MacKinnon and Dwyer, 1993). The first step is to establish that the independent variable (i.e. university antecedents) influences the mediator (i.e. Pasteurian orientation). This step is supported in model 7 above ($\beta = .194$, $p < .10$). The next step is to demonstrate that the independent variable (i.e. university antecedents and Pasteurian orientation) influences the dependent variable (i.e. overall performance). In this final step, as shown in model 8 of Table 3, the effect of university antecedents on performance is no longer significant when the mediator in the model is indicated, thus supporting the full mediation proposed in our argument (Aldwin, 1994; Baron and Kenny, 1986). Both the size of the coefficient for university antecedents and the corresponding test statistic for significant difference (t) decreased in model 5 ($\beta = .264$, $t = .004$, $p < .001$) and model 6 ($\beta = .247$, $t = .007$, $p < .001$). Interestingly, the control variable, engineering school, is found to have a positive relationship in commercial performance and overall performance.

Table 2 Means, Standard Deviations, and Correlations[a]

	Mean	s.d.	1	2	3	4	5	6	7	8	9	10	11	12	13
1.Department size	21.61	12.28													
2.College	.49	.50	.252*												
3.Engineer school	.40	.49	.079	.791**											
4.Medical school	.19	.39	-.308**	-.431**	-.401**										
5.Life & Science school	.10	.30	-.211*	-.332**	-.276**	-.163									
6. Strategic flexibility	4.43	1.31	-.159	-.077	-.069	.192	.042								
7. Balancing commitment	25.61	9.14	-.093	.046	.059	.146	-.141	.665**							
8. University antecedents[b]	120.81	69.33	-.146	-.010	.019	.240*	-.149	.804**	.945**						
9. Knowledge creation	39.40	3.06	-.084	.148	.095	.031	-.216*	.152	.130	.158					
10. Knowledge utilization	30.89	5.56	.126	.511**	.498**	-.211*	-.212*	-.045	.176	.108	.249*				
11. Pasteurian orientation[b]	70.28	6.70	.042	.437**	.409**	-.160	-.238*	.072	.236*	.198*	.682**	.857**			
12.Research publication	16.68	6.35	.259**	.237*	.127	-.122	-.172	-.236*	-.223*	-.245*	.020	.372**	.234*		
13.Research commercializ.	216.32	447.70	.113	.367**	.424**	-.182	-.085	-.105	-.084	-.087	-.062	.332**	.180	.222*	
14.Overall performance	4234.3	9790.9	.084	.349**	.399**	-.171	-.099	-.153	-.158	-.152	-.077	.322**	.164	.371**	.939**

[a] N = 99 departments.

[b] University antecedents is the multiplicative interaction of strategic flexibility and resource commitment. Pasteurian orientation is the multiplicative interaction of knowledge creation orientation and knowledge utilization orientation.

[+] $p < .10$; * $p < .05$; ** $p < .01$; two-tailed test

Table 3 Result of Regression Analysis[a]

Independent Variables	Model 1: PO (KC*KU)	Model 2: PO	Model 3: PO	Model 4: RP	Model 5: CP	Model 6: Overall Performance	Model 7: Overall Performance	Model 8: Overall Performance
Department size	-.054 (.604)	-.064 (.541)	-.057 (.580)	-.019 (.829)	.264** (.004)	.247** (.007)	.015 (.892)	.241** (.009)
College	.294+ (.069)	.292+ (.076)	.287+ (.075)	.129 (.358)	.082 (.567)	.090 (.533)	.094 (.575)	.087 (.545)
Engineer school	.126 (.418)	.141 (.371)	.128 (.407)	.191 (.158)	.290* (.038)	.389** (.005)	.320+ (.051)	.391** (.005)
Medical school	-.061 (.604)	-.039 (.744)	-.048 (.680)	-.133 (.184)	.007 (.946)	-.012 (.902)	.066 (.591)	.002 (.983)
Life & Sci. school	-.098 (.362)	-.126 (.248)	-.098 (.361)	.002 (.986)	.117 (.217)	.098 (.306)	.006 (.956)	.092 (.334)
Univ. antecedents	.191* (.047)						-.194+ (.054)	-.064 (.457)
Strategic flexibility		.107 (.258)						
Balancing commit.			.204* (.030)					
Know. creation				.511***(.000)				
Know. utilization					.321*** (.001)			
Pasteurian orientat.						.226* (.013)		.241** (.010)
ΔR^2	.033*	.011	.039*	.240***	.073***	.040*	.034+	.044**
R^2	.248	.226	.255	.438	.421	.418	.171	.421
Adjusted R^2	.199	.176	.206	.401	.383	.380	.117	.377
ANOVA F	5.065***	4.479***	5.235***	11.935***	11.141***	10.998***	3.169 **	9.461***

[a] For all models, N = 99. Standardized coefficients are shown.

+ $p \leq .10$; * $p \leq .05$; ** $p \leq .01$; *** $p \leq .001$

4.2 Post Hoc Analyses

In Figure 4, this study graphically represents the relationship between knowledge creation orientation and knowledge utilization orientation, which indicates a number of important insights. Most the departments cluster towards the middle. There are a few departments that rate very high on both orientations — the truly Pasteurian-orientation actors. However, many departments rate below average on both dimensions. Additionally, the result indicates a group of departments low on knowledge utilization orientation and average on knowledge creation orientation, and another group low on knowledge creation and average on knowledge utilization orientation.

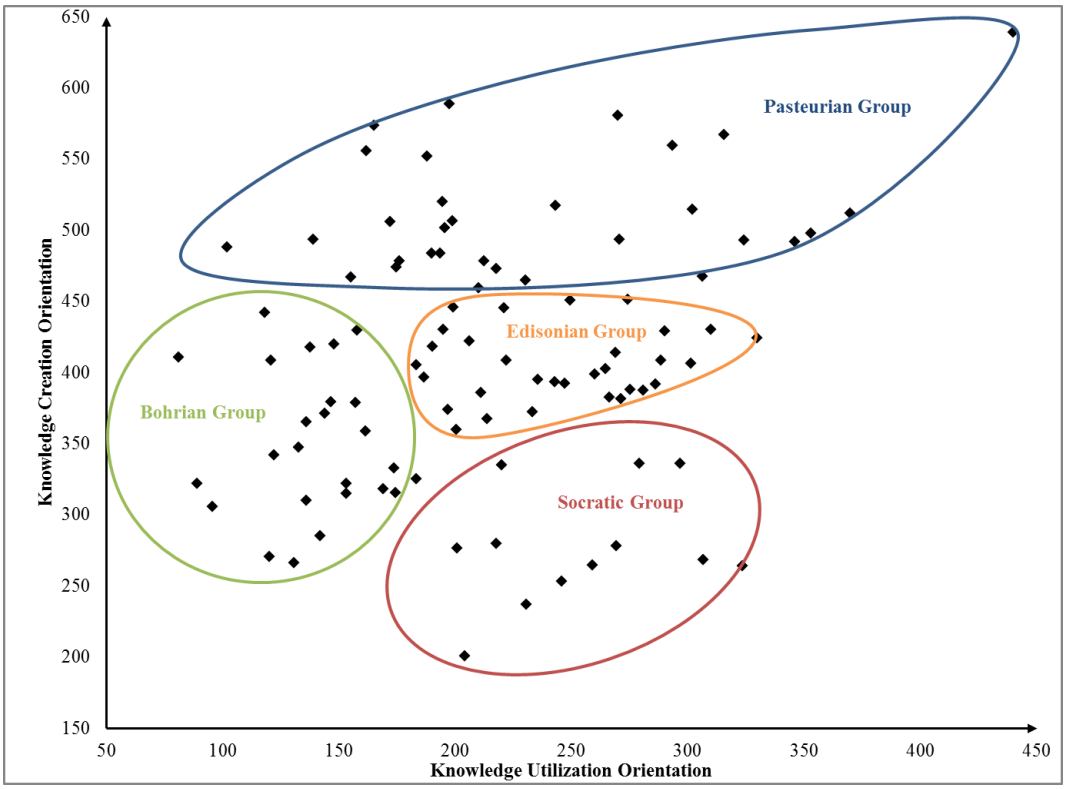

Figure 4 Plot of the Pasteurian orientation for the academic departments

In order to identify the meaningful clusters, this study undertakes a cluster analysis to position the specification of groups. Under the K-means algorithm (Hartigan, 1975), the four-group model provides the best fit. The appendix 1 indicates the knowledge creation orientation and knowledge utilization orientation scores the four cluster centers. Group 1 consists of 30 "Pasteurian group" departments, with high ratings on both dimensions. Group 2 consists of 12 "Edisonian group" departments, with higher ratings on knowledge utilization orientation than knowledge creation orientation. Group 3 consists of 31 "Bohrian group" departments, with higher ratings on Knowledge creation orientation than on knowledge utilization orientation. Finally, Group 4 consists of 26 "Socratic group" departments, and is with the below-average ratings on both dimensions.

In addition, results of both the ANOVA F-test ($F = 17.35$, $p < .001$) and the discriminate test of Wilks' Lambda value are statistically significant ($p < .001$). These findings indicate that all four groups are different form one another. The Pasteurian

group has the best performance, followed by the Edisonian group, Bohrian group, and Socratic group. The highly Pasteurian orientation group outperformed those that are only knowledge creation or only Knowledge utilization orientation, suggesting that the ability to be Pasteurian-oriented is an important predictor of the performance.

5 Discussion

These findings raise important theoretical and practical issues for discussion. First, the findings suggest that the university context is a critical determinant for the development of PO in the departments. Specifically, *strategic flexibility* and *balancing commitment* combine as contextual antecedents that influence the departments in fostering PO. Specifically, balancing commitment has greater influence than strategic flexibility. The influences of resource-based contexts are greater than those of the strategic contexts in the universities. This study argues that the university antecedents provide important signals for the subordinated departments to redefine their academic routines. This finding supports the view that faculty members' decisions to conduct entrepreneurial involvement are socially conditioned (Shane, 2004b). Furthermore, it is aligned with the argument that developing ambidextrous contexts within universities can be efficient to simultaneously pursue academic research findings and academic research commercialization (Birkinshaw and Gibson, 2004; Chang et al., 2009). Both research income and satisfaction from seeing research brought into application are critical for faculty members to maintain university-industry interactions (D'Este and Patel, 2007). Universities are suggested to design the contextual antecedents of resource availability and strategic flexibility to enable the departments to engage in knowledge creation and knowledge utilization.

Second, the capacity for PO has a substantial impact on the subsequent performance of knowledge creation and knowledge utilization. Specifically, this study does not find a trade-off between knowledge creation orientation and knowledge utilization orientation. The empirical finding is consistent with the argument that research publication and research commercialization are more complementary, rather than contradictory, within university departments (Van Looy et al., 2006; Tushman and O'Reilly, 2007). University researchers are motivated to interact with industry in order to enhance their variety and integration skills in knowledge exploration (D'Este and Patel, 2007). University departments are suggested to create a sub-context that empowers faculty members to make their own decisions as to how divide their involvement between knowledge creation and knowledge utilization activities. This finding supports the results of prior research arguing that academic research commercialization actually augments the academic research works themselves (Ambos et al., 2008; Bercovitz and Feldman, 2008; Chang et al., 2008).

Third, the PO capacity is acting as a critical role for departments to leverage the university antecedents on subsequent research performance. However, the level of PO varies across universities and research fields which suggest that it is likely to be a critical capability for many, if not all, universities and research institutions. In our sample, all the universities have department(s) belonging to the Pasteurian group, and University C is the only institution with no department in the Socratic group. This finding further support our argument that institution-specific settings have substantial impacts on university antecedents. Any kind of university has the possibility of nurturing more departments toward the Pasteurian group. Accordingly, University A, University B, and University C have built-up Research Excellence Centers that emphasize the functions of knowledge creation and knowledge utilization. Moreover,

the focus of University D and University E on a fundamental research orientation thus influences most of their departments to move toward a knowledge creation orientation.

Moreover, most of the departments in the Pasteurian group are engaged in the field of engineering research, and fewer of them belong to Socratic group. Conceptually, the departments of natural science fields tend to focus on knowledge creation and create knowledge utilization around it. The departments of engineering research fields have the highest possibility, while the departments of biological fields had the least, to achieve high PO capacities. On the one hand, these findings should be relevant to the high-tech industrial environment in Taiwan. And on the other hand, university-industry collaborations may provide substantial feedback on research publication and research commercialization, especially for engineering fields. In accordance with Lim (2004), the impact of research findings on innovation can be different according to industrial context. Specifically, semiconductor firms rely a great deal more on applied than on basic research, while pharmaceutical firms rely slightly more on basic than on applied research. Future research to investigate departments within as industry environment that is surrounded by non-engineering industries would be an important extension of our study.

As research disciplines are shaped by multiple contextual factors, the ways in which disciplinary departments could contribute to economic and social development vary from each research background. Professional norms in different discipline influence the focus of research, in ways such as customs, traditions, and reward systems (Beesley, 2003; Searle, 2006). The individual research disciplines also have their own boundaries in terms of knowledge production (Tierney and Holley, 2008), and the disciplines have their own history, directed towards solving different questions or needs in society or industry. In this study, the applied disciplines like engineering or medicine are likely to be more closely tied to the applications, and most of these applications are oriented towards needs of the industrial sector. In contrast, the disciplines oriented towards fundamental understanding, such as pure physics or philosophy, are less direct and would be in need of more long-term development to support future industrial development. In short, some disciplinary departments legitimately operate in Bohr's quadrant, and some operate in Edison's quadrant. However, Stokes's challenge shapes the work of research disciplines that jointly value the scientific and economic purposes (Tushman and O'Reilly, 2007), and that reflecting to the concept of PO in this study.

Therefore, accompanying the shift of the model of knowledge production to "Mode 2," which emphasizes interdisciplinary research solving problems across different disciplines, research boundaries within disciplines have become blurred (Stephens et al., 2008; Tierney and Holley, 2008). Moreover, inter-disciplinary orientation causes research disciplines in the Bohr's and Edison's quadrants to move towards Pasteur's quadrant. Researches in the Bohr's quadrants become involved in providing basic solution to problems of technological development. In other words, the research in the Edsion's quadrants needs more explorations in basic research to broaden its depth of knowledge. Some research disciplines have a more "Pasteurian orientation" because the cost of investment and risk is high, such as biotechnology and genetic technology. In addition, some disciplines develop PO more easily because knowledge production and application tend to accompany their research, such as bioengineering, pharmacy and nano-sciences (Uranga et al., 2007).

6 Conclusion

This paper examines how universities can develop new organizational structures to cope with the rise of academic entrepreneurship. Unlike previous studies that focused only on universities or their faculty members, this study uses departments as the unit of analysis and verifies their intermediate role in stimulating academic entrepreneurship. By supporting the Pasteurian quadrant framework, university departments of various research backgrounds can be classified into four major groups including "Pasteurian group," "Edisonian group," "Bohrian group," and "Socratic group". The PO capacity is verified to be an appropriate measurement of the knowledge involvement of university departments. Along with the hierarchical structure of universities, departments and faculty members, the relationships between contextual antecedents, PO capacity, and research performance are further analyzed.

This study contributes to a realization that institutional characteristics (i.e. university contexts and university departments) act differently in fostering faculty members to achieve both knowledge creation and research utilization. Initially, universities are suggested to construct contextual antecedents such as strategic flexibility and balancing commitment to foster the capacity of PO. This hybrid structure not only focuses on knowledge creation but also on knowledge utilization. Subsequently, university departments should take a mid-level position between research finding and research commercialization. PO acts as an important capability through which departments can foster and can be shaped through a supportive university context. Ultimately, university and department collectively can put in place systems that allow nourishing contexts to emerge, in turn shaping individual faculty members' attitudes and behaviors.

Academic contexts and disciplinary attributes are likely to be the greatest endogenous factors affecting the development of PO. The institutional contexts influence PO by the policy, attitude, and academic capitalism, while organizational contexts determine the strategic flexibility and resource availability. The organizational changes provide legitimacy to involve the industry more closely with the faculty members (Chreim et al., 2007). In addition, the changes provide support to sponsor the faculty member's engagement with knowledge utilization (Bramwell and Wolfe, 2008). Finally, the individual factors demonstrate the willingness of the faculty members will influence the implementation of PO.

The implications for management and policymakers are follows. For university administrators, the development of entrepreneurial universities needs to be considered according to the characters of the contextual antecedents in each university. Resource balancing and strategic flexibility are the core element of contextual antecedents that influence departments. For department heads, PO can be created through structural and contextual approaches to enhance research excellence and commercial success. For technology transfer officers, university departments that are high in both research disclosure and research commercialization have more potential for facilitating technology transfer.

As for the various research backgrounds, policymakers should be cautious in valuing entrepreneurial performance by incorporating IPR with non-IPR-based approaches. Moreover, this study highlights that the current institutional environments in Taiwan have not yet persuaded university departments to adopt a Pasteurian orientation in the involvement of spin-off creation. Policymakers are suggested to re-examine the current program for evaluating universities and researchers that are limited to focusing mainly on research publications, patent grants, and technology transfers.

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Appendix 1 Result of Post Hoc Clustering Analysis

Group & University	Departments	Overall Performance	Group Rating			
			Knowledge Creation Orientation	Knowledge Utilization Orientation	Number of Departments	Mean Performance
Pasteurian Group			406.64	246.62	30	328.69
University 1	Bio-Industrial Mechatronics Engineering	253.89				
	Biomedical Engineering	589.94				
	Communication Engineering	231.93				
	Electronics Engineering	664.73				
	Entomology	199.00				
	Food Science and Technology	178.18				
	Horticulture	49.92				
	Life Science	198.40				
	Mechanical Engineering	326.50				
	Oral Biology School of Dentistry	263.03				
	Photonics and Optoelectronics	194.00				
	Science and Ocean Engineering	961.78				
	Toxicology	248.44				
	Veterinary Medicine	218.86				
	Zoology	383.23				
University 2	Biomedical Engineering	145.96				
	Electrical Engineering	326.44				
	Engineering and System Science	554.87				
	Nuclear Engineering and Science	382.50				
University 3	Biological Science and Technology	322.31				
	Computer Science	221.09				
	Materials Science and Engineering	556.50				
	Mechanical Engineering	434.65				
University 4	Biomedical Engineering	513.11				
University 5	Biomedical Engineering	187.43				
	Chemistry	182.02				

	Information and Computer Engineering	196.47				
	Mechanical Engineering	347.22				
	Physics	171.32				
University 6	Optoelectronics Engineering	357.08				
Edisonian Group			277.43	254.44	12	309.11
University 1	Biochemical Science	151.84				
	Civil Engineering	293.52				
	Immunology	123.36				
	Materials Science and Engineering	465.2				
	Pharmacy	177.48				
	Photonics and Optoelectronics	231.93				
University 2	Chemical Engineering	416.75				
	Nan Engineering and Microsystems	197.5				
	Power Mechanical Engineering	343.92				
University 3	Applied Chemistry	628.24				
	Civil Engineering	388.06				
University 4	Environmental and Occupational Health Sciences	291.46				
Bohrian Group			512.30	235.68	31	237.11
University 1	Anatomy and Cell Biology	299.61				
	Applied Mechanics	295.80				
	Atmospheric Sciences	103.82				
	Chemical Engineering	611.17				
	Dentistry	169.24				
	Electrical Engineering	343.28				
	Forestry and Resource Conservation	199.60				
	Molecular Medicine	184.95				
	Physiology	43.70				
	Public Health	301.29				
University 2	Communications Engineering	344.67				
	Computer Science	229.35				
	Industrial Engineering & Management	311.70				
	Materials Science and Engineering	381.20				

	Mathematics	116.33				
	Photonics Technologies	288.00				
University 3	Electrical Engineering	377.41				
	Electronics Engineering	221.23				
	Electronics Physics	243.60				
University 4	Dentistry	162.25				
	Traditional Medicine	129.26				
University 5	Bioenvironmental Engineering	98.60				
	Chemical Engineering	321.24				
	Civil Engineering	68.17				
	Electrical Engineering	146.92				
	Electronics Engineering	239.33				
	Nanotechnology	477.03				
University 6	Automation and Control Engineering	104.90				
	Computer Application Engineering	183.31				
	Computer Science Engineering	267.50				
	Electrical Engineering	85.87				
Socratic Group			350.74	141.61	26	182.23
University 1	Agricultural Chemistry	30.83				
	Agronomy	318.22				
	Animal Science and Technology	92.80				
	Biochemistry and Polymer Biology	88.11				
	Geosciences	155.25				
	Heath Care Organization Administration	292.97				
	Oceanography	206.98				
	Physical Therapy	206.96				
	Physics	490.25				
	Polymer Science and Engineering	573.12				
	Psychology	162.39				
University 2	Biotechnology	117.95				
	Chemistry	195.00				
	Electronics Engineering	287.04				

	Life Science	97.44
	Molecular and Cellular Biology	84.00
	Physics	319.95
University 4	Biochemistry and Molecular Biology	192.50
	Life Science	127.83
	Microbiology and Immunology	49.16
	Oral Biology	118.20
	Public Health	50.63
University 5	Applied Mathematics	88.88
University 6	Energy Application Engineering	119.50
	Materials Science and Engineering	157.83
	Mechanical Engineering	114.21