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epartments respond to the rise of academic entrepreneurship? : The Pasteurâ€™s q

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Abstract

The paper proposes the notion of Pasteurian orientation in the university and examines how university departments respond to the Pasteurian orientation. The paper uses an instrument to measure university antecedents, the Pasteurian orientation and research performance. Via a survey of the university executives and faculty members in 6 universities, 634 respondents originated from 99 departments are collected. Findings indicate that university antecedents with the higher strategic flexibility and resource commitment contribute the greater Pasteurian orientation. The higher degree of

Pasteurian orientation in university departments has significantly positive impacts on their research performance. Moreover, the Pasteurian orientation of university departments acted as a mediator within university antecedents and performance. Via cluster analysis, the paper categorizes four groups of 99 departments (from 40 schools, 6 universities) into: Pasteurian, Bohrian, Edisonian & Socratic groups. The differences of the university- (organizational), discipline- and individual factors between four groups are examined and discussed. We conclude that not all academic departments move toward the Pasteurian group. There are specific organizational and disciplinary factors resulting mobility barriers among groups. The policy to encourage academic entrepreneurship should be aware of these group mobility barriers along with the emerging new governance of S&T.

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1. Introduction

The utilization of academic research in the last several decades has stimulated an expansion of scholarly investigation from the issue in the science governance (e.g. Merton 1968; Dasgupta and David, 1994; Stokes, 1997), the academia-industry linkage (e.g. Stankiewicz, 1986; Geisler and Rubenstein, 1989), the triple helix model (Leydesdorff and Etzkowitz, 1996), and academic entrepreneurship. (Etzkowitz, 2003; Shane, 2004b) And, these researches show that universities have high potential in contributing economic and social development. Accompanying with the change in S&T policy and the transformation in economy, the universities are undergoing to build the third mission that contributes to social and economic development. (Etzkowitz et. al, 1998; Molas-Gallart, 2004) The entrepreneurial activities in universities involve the process that enables the researches from the laboratories to be disclosed and proven their novelty and originality, and be channelled into the marketplaces, such as patenting, licensing, and spin-off venturing. The rise of academic entrepreneurship enforces the universities to change the policies, structure, resource allocation, and so on, in order to keep original mission going and develop the new mission. (Shane, 2004a；Powers and McDougall, 2005)

So, how do we to enhance the universities toward to entrepreneurial universities? Many researches propose different factors from the institution to the individual. There are many researches show that the institution and regulations influence the context of entrepreneurial universities, such as mission, structure, resource allocation, and performance evaluation. (Mowery et al., 2001; Whitley, 2003; Etzkowitz, 2003; Chreim et al., 2007; Jain et al., 2009) Then, some scholars find that organizational support strongly influences the faculty behavior, and including the nom's, peer pressure, behavior of reference group, and specific mechanism agencies. (Bercovitz and Feldman, 2008; Jain et al., 2009; Haas and Park, 2010) Otherwise, different academic career stage (Dietz and Bozeman, 2005), the experience (Ambos et al., 2008), and the resource (D'Este, and Perkmann, 2010) would influence individual's engagement in entrepreneurial universities

The paper develops the notion of Pasteurian Orientation (PO) as a framework in development of entrepreneurial universities. The PO explains the feature of entrepreneurial universities that reach the quest of understanding and contribute the quest of practical using simultaneously. In addition, each orientation contains organizational support and faculty's engagement to explain each development in the organization. Then, this study employs the framework to measure universities dual effort between Knowledge creation orientation and Knowledge utilization orientation. And, there is little research to examine ambidextrous efforts in entrepreneurial universities. What kinds of university antecedents can cultivate better PO? How do the universities develop organizational and individual supports towards PO. Do the higher of PO facilitate better ambidextrous performance? Which departments or disciplines can develop better PO?

Moreover, the paper applies multiple-level analysis, including the universities, departments, individuals, to explain the development of entrepreneurial universities. And, using cluster analysis finds out which departments are Pasteurian departments.

In the next, we review the literatures about the new challenge of universities, describe the change in university departments, and propose our hypotheses. Via the survey, this study collects the data from 634 respondents, 99 departments, and 6 universities in Taiwan to verify our hypotheses. Finally, we combine the result with cluster analysis and provide the explanations and implications from this study.

2. Theoretical Model

2.1 The rise of academic entrepreneurship

Since the postwar to 1980's, the universities focused on the basic research to contribute the public knowledge creation. (Stokes, 1997) After the 1980's, there are some radical changes to influence the role of universities. In the government, financial support is decreased by increasing number of new universities and constraints on public expenditure. In the industry, the firms face the strong competitions in technology development, and stress on connecting with the long-term research and approximating to basic research to cultivate the core competences. To solve the problems, many stakeholders promote the universities need to integrate into the system of innovation. For the universities, they could get the grants from new sources and more contribute to the society. And, the industries could also build the relationship with the universities to get the advanced technology and to develop the technology capabilities, even to retain the human resource. (Martin, 2003)

There are three approaches about this issue. First, in science-governance approach (e.g. Merton 1968; Dasgupta and David, 1994; Stokes, 1997; Mckelvey, 1997; Nelson, 2004), these scholars think academic researches don't only to contribute knowledge creation, but also could support to the developments in the application exists the economic benefit.

Second, in the triple-helix approach (e.g. Leydesdorff and Etzkowitz, 1996; Etzkowitz, 1998; Etzkowitz and Leydesdorff, 2000), they consider the universities play an important role to enforce the innovation in specific region, because they take an advantage in gathering and accumulating the talents, knowledge, and resource. The industrial firms could leverage these through triple-helix network, governments, universities, and firms, and it would rise up the innovation in the region. Third, in the academic- entrepreneurship approach (Etzkowitz, 2003; Shane, 2004b), such as entrepreneurial university, academic entrepreneurship, and so on ,the scholars emphasize the universities must play a positive role in the knowledge economy through different mechanisms, such as technology transfer, contract research, patent licensing, even spin-off. Etzkowitz (2003) argue that the entrepreneurial university generates two goals in creating knowledge and translating the knowledge to make the universities fulfill with economic and social need directly.

Above of all, we could find the universities' researches actually imply multiple values, and

the universities are undergoing the second revolution not to just for knowledge creation, but also support social and economic development in knowledge economy, and we calls “entrepreneurial universities.” (Etzkowitz, 1998; 2003) The universities must alter their norms to fit the change in science policy and rethink the relationships with the external stakeholders.

2.2 Entrepreneurial Universities and Pasteur’s quadrant

After the World War II, the research divides to two streams which avoid the privatization of knowledge and keep be public good. The government funds the researches that focus on the understanding of nature. In contrast, the firms invest the innovation of new technologies to apply. (Stokes, 1997; Goldfarb, 2008; Mendoza, 2009) Vannevar Bush (1950) defined the research attributes to basic and applied research, and the Frascati Manual(1970) modified the dichotomies from pure basic research and to experimental development on one dimensional linear spectrum that connect between knowledge development and technological innovation. (Stokes, 1997; Beesley, 2003; Goldfarb, 2008)

Stokes (1997) cites the research of Louis Pasteur drive toward understanding of microbiologic process and control food spoilage and microbial-based disease as a good example. (Mendoza, 2009) And, he proposes a new matrix (See figure) of consideration in utility and fundamental understanding for strategic research. (Beesley, 2003) For the research of universities, we revised with the purposes to two related axes. One is knowledge creation that tries to improve our understanding in the knowledge. Another is Knowledge utilization orientation that the research tries to resolve the technology problems or enforce the innovation.

The upper left cell, the Bohr’s quadrant, focuses on the basic research without the consideration of practical application. And, the lower-right cell, the Edison’s quadrant, concretes at the research of technology development that just considers the utilization of knowledge. Then, Stokes (1997) proposes a new conceptual quadrant, the Pasteur’s quadrant, which focuses on the basic research inspired by understanding and by use. He argues that the researches in Pasteur’s quadrant is the better position for strategic research because the user-inspired basic research could move flexibly to Bohr’s quadrant to increase the understanding and to the Edison’s quadrant to apply into practical using, and the interactions between them forms a revised dynamic model. Finally, the lower-left quadrant, Stokes (1997) argues the research contains the work neither creating nor using, and just focuses systematically explores particular phenomena, a taxonomic researches, ex. bird watching, and history , and Stokes(1997) take Peterson as example, but keep no names. Moreover, Reeves (2006) thinks the research in the quadrant target the instrumental and educational developments a forward to the activities in Bohr’s and Edison’s. In this study, the researches in this quadrant are characterized that focus on systematize our knowledge and the applications are the fundament for practical using. The paper cites a Socrates as example, he focuses on developing a methodology to systematize the knowledge, and distribute by education. Moreover, Confucius is also the example that systematizes and interprets ancient’s knowledge, and

educates the people to influence future using. Thus, we call the lower-left cell as Socrates' quadrant.

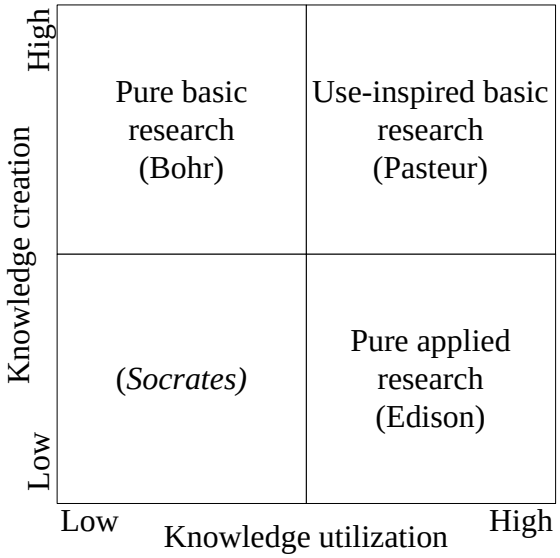

Figure 1 Quadrant Model of Scientific Research

Source: Adapted from stokes (1997)

For the universities, Etzkowitz (2003) argues that the research has transformed gradually to interact between the basic and applied researches in the linear model, and move from the understanding to utilization. In Stokes' Model, entrepreneurial universities would make the researches toward to Pasteur's quadrant.

Pasteurian orientation is described organizational attributes that the notion of PO can be defined as "a university develops a dual goal, strategy, structure to achieve knowledge creation and knowledge utilization."

Both of activities rely on organization support and faculty engagement. They need organizational support, such as investing the resource, training the capabilities, providing the incentive and mechanism to encourage faculty's involvements. (Bercovitz et al., 2001; Etzkowitz, 2003; Geuna, and Muscio, 2009; D'Este, and Perkmann, 2010) On the other hand, the faculty's engagement is not only influenced by the organization, but also by individual's capabilities, resource, career planning, and commitment. (Owen-Smith and Powell, 2003; Bercovitz and Feldman, 2008; Jain et al., 2009; D'Este, and Perkmann, 2010)

In the summary, the paper proposes a conceptual model of PO. The degree of PO determine on two orientations, Knowledge creation orientation and utilization. And, the operations in each sub orientation rely on the combination of organizational support and faculty's engagement.

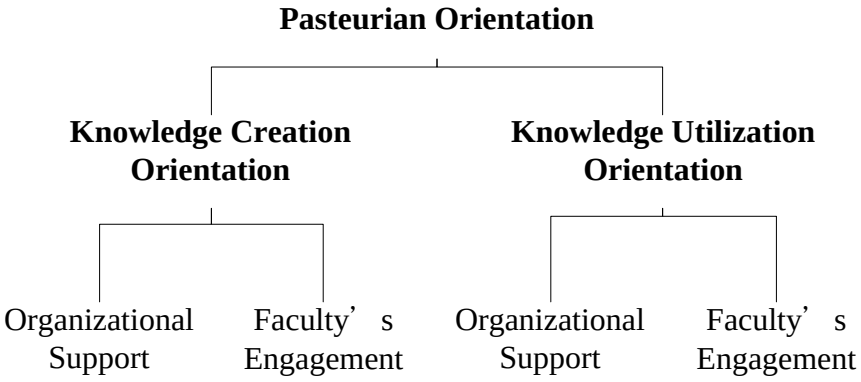

Figure 2 Decomposition of Pasteurian Orientation

2.3 University-level facilitators for the Pasteurian orientation of departments

In the past decades, the universities have become the most important source of knowledge in the innovation system. (Nelson, 2004) These changes in institution influence the whole arrangements that the funding source become diversifying, the criteria of performance also emphasize on non-academic production, and the impact to industry has become another achievement. The governments redefine the policy toward to make the universities be "Pasteurian orientation.", and enact a series of acts to deregulate the limitations and encourage the universities' to engage in the industry and society.

For example, the Bayh–Dole Act and a series of acts to help the universities develop the third mission. In the prior empirical studies, ex. Mowery et al. (2001), and Shane (2004a), find that the Act really provides a strong incentive to the patenting activities of universities, even enforces the commercialization of inventions.

From the point, the universities develop different portfolio by accompanying different intellectual, economic, and social context with the expectation of the universities. The universities have changed their infrastructure and organizational support to shape new strategy that hybrid the multiple missions, such as the establishment of the technology transfer office (TTO), the investments in the commercialization, the support mechanisms, and even redefine the criteria in performance evaluation. (Stankiewicz, 1986; Etzkowitz, 2003; Beesley, 2003; Geuna, and Muscio, 2009) The universities show their evidence that create dual structure to be able to manage the tension between the academic and commercial need. (Ambos et al., 2008; Chang et al., 2009) The organizational context evolves to new paradigms, and makes the disciplinary departments change to Pasteurian orientation that pursue the knowledge creation and connect with the industrial workings. Thus:

Hypothesis 1：The more a university context is characterized by an interaction of strategic flexibility and balancing commitments, the higher level of Pasteurian orientation of departments is.

Some science and technology (S&T) policy researchers claim to have adopted a 'new public management' that increases the efficiency of the universities' operation and economic effectiveness. (Cox et al., 1999) Many universities establish the infrastructures, such as patent offices, technology liaison offices, and university-affiliated incubator, to dedicate the commercialization. (Mowery et al., 2001)

The management of multiple functions reflects the need of differentiated organizational adjustments in universities. Based on the concept of strategic adjustment, there are a lot of organizational reconstructions being designed to enhance academic researchers' economic sensitivity of scientific outcomes derived from research projects. At the same time, the universities keep the origin mission make the departments could flexibly set their goals by different portfolio. Thus:

Hypothesis 1a：The higher strategic flexibility in a university context, the higher level of Pasteurian orientation of departments is.

However, the resource in universities is usually limited. Academic researchers undertake research initiatives not only to satisfy their own scientific curiosity, but also to comply with resource commitments from various organizational levels. Swamidass and Vulasa (2009) find asymmetric information between academic inventors and IPR management challenge the willingness of invention disclosure. Universities are suggested hire researchers who willing to work close to the boundary of technological applications. (Geuna and Nesta, 2006)

Many researchers finds academic scientists who have industrial contacts can reinforce their research capabilities beyond what would be allowed by core academic funding (Etzkowitz, 2003; Shane, 2004b). And, the performance measurement or reward system is another important factor to enforce the department and the faculty be PO. The criteria (such as publication, patent number, U-I project number, industrial services, and so on) on hiring or promoting doesn't just concern about the publication or impact in the knowledge field but also concern to contribute to industry. A new reward system makes the departments and faculty commit to fulfill the requirements. (Beesley, 2003; Whitley, 2003; Geuna, and Muscio, 2009)

In the short, the resource allocating and reward system refining push the departments and faculty balancing the commitment in research and industrial workings. Thus:

Hypothesis 1b：The higher balancing commitment in a university context, the higher level of Pasteurian orientation of departments is.

2.4 Pasteurian orientation and overall research performance in university departments

Prior researches argue universities create structural and contextual mechanisms for managing entrepreneurial activities are found to have differentiated and complementary influences in stimulating research commercialization (Chang et al., 2009). The current academic paradigm simultaneously stress on scientific and economic contributions.

For the faculty, there are many factors that influence them involving into Knowledge

creation and utilization. Renault Searle (2006) finds that the belief of professors about the research commercialization and the proper role in third mission would influence entire decision-making processing. Davis et al. (2009) find the capability would influence the professors' involvement. Moreover, the different academic career stage (Dietz and Bozeman, 2005), the experience (Ambos et al., 2008), and the resource (D'Este, and Perkmann, 2010) would influence individual's engagement. Jain et al. (2009) also find the networks that the faculty could access are important incentives to engage in the commercialization.

However, the departmental support is also an important factor. First, the professional norms or organizational identities are shaped by the attitude and behavior of reference groups that compose with the colleagues or similar disciplinary scientists would influence the individual's behavior when there is a conflict between the group and the individual. (Bercovitz and Feldman, 2008; Jain et al., 2009; Haas and Park, 2010) Second, the department is the centralization of control over the goal, resource, and career within and between the universities and similar organization. (Whitley, 2003; Renault Searle, 2006) In other words, the support from the department and individual co-exist that would influence the performance in Knowledge creation orientation and 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 departmental and individual supports for Knowledge creation orientation, the higher research publication of the departments is.

H2b: The higher coexistence of departmental and individual support for Knowledge utilization orientation, the higher research commercialization performance of the departments is.

Moreover, Stokes (1997) also thinks the research in Pasteur's quadrant could enhance research performance because of considerations in Knowledge creation orientation and utilization. And the majority of existing research has shown a positive relationship between the academic outcome of the researchers and the likelihood of their involvement with commercial activities, and the researchers are high performance. (Di Gregorio and Shane, 2003; Owen-Smith and Powell, 2003; Van Looy et al., 2006) Thus, we propose the following hypothesis.

H2c: The higher departmental and contextual dual supports of Knowledge creation orientation and Knowledge utilization orientation, the higher overall performance of university departments is.

2.5 Mediation Effects of Pasteurian orientation

This study argues that PO mediates the relationship between the two antecedents of

university context and subsequent university departments' performance. That is, the two university antecedents influence performance through the development of PO.

Prior researches argue that the mediating effect of the contextual duality occurs because the features of the antecedents themselves can create and amplify internal tensions if they do not contribute to the simultaneous capabilities for knowledge creation and knowledge utilization (Ambos et al., 2008). Moreover, we also think PO which comprise by the support from the department and individual in knowledge creation and utilization would influence overall research performance. PO create bottom-up context, and interact with the change of university's antecedents to influence research performance.

So, we argue that PO contributes to university antecedents, which then leads to university department's performance. Thus, we suppose as the following.

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 research framework and the corresponding hypotheses in Figure 1. Specifically, superior department performance is expected to be achieved by building the capacity of strategic adjustment and balancing commitment that collectively define a university context that allows the meta-capabilities of knowledge creation and utilization to simultaneously flourish.

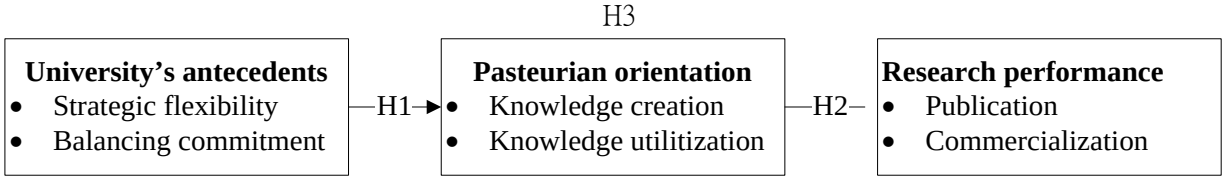

Figure 3 Research Model

3. Methods

3.1 Questionnaire development

3.1.1 Item development

As suggested by Gibson and Birkinshaw (2004), this study collect the data by asking a large sample of individuals to rate their universities and departments on the antecedents and development in PO, and then to aggregate their responses to create unit-level measures. Because no existing measure assesses universities' antecedents and PO in academia, we develop the survey after referred to a few items identified by Ghoshal and Bartlett (1994) and Chang et al. (2009). The questionnaire is written in English that is translated into Chinese and then back-translate them into English. A cover letter attaches with the questionnaire explains the research purpose and provided assurances of anonymity and confidentiality.

3.1.2 Judge analysis

We recruit 15 faculty members and doctoral students as subject matter experts to judge the content of the draft questionnaire. Moreover, we hold three focus groups to discuss these questions. The percentage of correct assignment is calculates for each item by using items with 60% or higher correct classification. Based on descriptions and interviews, 40 questions are chosen to measure the questionnaire. Among those, there are 15 questions assessed for university's antecedents, 17 questions for the development in PO, and 8 questions for performance.

The items of university's antecedents and the development in PO in the survey are developd in 7-point Likert-style. To mitigate the problem of common method bias, this study uses different levels of respondents for the independent variables (university's antecedents) and the dependent variables (Pasteurian orientation and performance). Specifically, the executives are merely responsible for the items of university's antecedents. And the non-executive faculty members are required to answer the items of Pasteurian orientation and performance. That is, for the independent variables we aggregate only those respondents who identify themselves as executives. For the dependent variables, we aggregate only those respondents who identify themselves as non-executive faculty members.

3.2 Participants

The survey items are 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 is clear.

The sampling criterion focuses on university departments of science, engineering, and medical research fields since they have higher potential to commercialize research results. Prior research argues that the goal of theoretical sampling is to choose research targets which are likely to replicate or extend existing theory (Eisenhardt, 1989). Accordingly, six major universities in Taiwan are chosen and the original list of 29 schools and 172 departments is collected from the schools' websites.

After checked with the researcher database in the National Science Counsel for the consistency, the total number of survey respondents is 2,868 individuals from these departments. And, this study 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. To meet the analysis criteria, we require a valid department to be contained with one executive and four faculty members at least. Finally, there are 711 returned questionnaire (a 26% response rate). 77 surveys are dropped because not matching the criteria of a valid department. Thus, there are 634 valid questionnaires which stand for 27 schools and 99 departments (a 58% of the population).

The respondents who have completed the survey data are consisted of 157 executives and 477 non-executive faculty members. The executives served as deans/directors/chairs at 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 have been granted as tenured faculty members. Table 1 provides a brief breakdown of the sample.

Table 1 Characteristics of the Sample Universities

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

3.3 Measures

3.3.1 Performance

To better reflect the qualitative and quantitative attributes of performance, this study employs subjective and objective approach to investigate the performance. The subjective research-unit performance is measured by obtaining faculty members' response to two 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. There are five items being 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 faculties encouraged by incentives of my department have high job performance" and (5) "The overall performance of my department is high". The five items loaded on a single factor having an eigenvalue of 2.38 (α = .86). We rename the factor as *Subjective Performance*. As for the objective approach, this study initially require the respondents to convey their research publication (i.e. journal paper published in the databases of SCI, SSCI, and EI) and commercial outcome (i.e. patent grant, technology transfer, university-industry collaborative project, and spin-off) over the last three years. Moreover, as suggested by Gibson and Birkinshaw (2004), we create an interaction term

using the multiplicative interaction of the research publication variable and commercial outcome variable.

3.3.2 Pasteurian orientation

We conceptualize PO as two dimensional constructs comprised of the context of Knowledge creation orientation and Knowledge utilization orientation are expressed by pursuing the knowledge creation and utilization. We measure knowledge creation by asking faculty members to indicate the degree to which they agree with the following: (1) “The research facilities and environments in my working department/institute are excellent”, (2) “The awards of research excellence are extremely stressed in my working department/institute”, (3) My supervisor(s) and I have reached a consensus of pursuing research excellence”, and (4) “My colleagues and I have reached a consensus of 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 being condensed to one factor including: (5) “My research topics cover both incremental and radical breakthrough”, (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”. The three items loaded on a single factor having an eigenvalue of 1.81 (α = .72). We rename the factor as Research Engagement. Specifically, the two factors have accounted for 65 percent of the variance. Moreover, we computed the multiplicative interaction between Research Support and Research Engagement, reflecting research publication as the *Knowledge Creation Orientation* activities 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 incentive for technology transfer are superior in my university”, (3) “The guidance and incentive for IPR application are superior in my university”, and (4) “The guidance and incentive for creating spin-off are superior in my university”. The four items loaded on a single factor having an eigenvalue of 3.69 (α = .95). We rename the factor as Commercialization Support. Additionally, there are four items being 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 to conduct my research exploitation”. The four items loaded on a single factor having an eigenvalue of 2.87 (α = .89). We renamed the factor as Commercialization Engagement. Specifically, the two factors have accounted 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 the *Knowledge Utilization Orientation* activities 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's antecedents by developing 11-item scales to represent the dimension of strategic flexibility and balancing commitment identified by Chang et al. (2009). Factor analysis identifies these items to cluster together as three factors. One of the factors represented a combination of the items developed for the antecedent, strategic flexibility. Other two factors represented the specific combinations of the items regarding balancing commitment in forms of research works and commercialization works.

Specifically, the executive respondents indicated the following items encourage people at their level: (1)"My university would often set up cross-department committee to response external ongoing opportunities", (2)"My university would often set up cross-department committee to reconfigure inappropriate regulation", (3)"The management mechanism of my university would rapidly response and adjust the priority of organizational goals", (4)"My university would often set up temporary mission-oriented committee to integrate resource allocation and reconcile potential conflict", and (5)"My university has established a new unit/institution to integrate resource allocation and reconcile potential conflict" . The five items loaded on a single factor having an eigenvalue of 3.23 and accounting for 52 percent of the variance (α = .88). And, we renamed the factor as *Strategic Flexibility'*.

Moreover, the executive 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". The three items load on a single factor having an eigenvalue of 6.96 (α = .95), and reflect the commercial involvement in the dimension of balancing 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". The three items load on a single factor having an eigenvalue of 8.40 (α = .85), and reflect the research involvement in the dimension of balancing commitment. Finally, we create a term *Balancing Commitment* (Whitley, 2003).

3.3.4 Control variables

This study employs three control variables to reflect the different characteristics of the department. One is the number of faculty in the department, count as 'department size' by 2868

survey respondents is affiliated. (e.g. Lach and Schankerman, 2008; Ambos et al., 2008; D'Este, and Perkmann, 2010) Then, we use serveral variables represent the orientation of department. 'College' is dummy variable that separate by the name of college which the departments belong, and 1 is the college with high potential for commercialization, including Engineering, Life science, and Medical. In addition, we create some subfields as dummy variable which the departments belong, including Engineering, Life science, and Medical. (e.g. Ambos et al., 2008; D'Este, and Perkmann, 2010)

3.4 Aggregation

Each of the variables in our model represented research-unit characteristics, but we utilize individuals as raters of those characteristics. In the parlance of multilevel theory (Klein and Koslowski, 2000), our paper 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 professors are most familiar with the extent to which their department exhibits certain attributes of a university's antecedent, as well as Pasteurian orientation and 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 calculate 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) suggested .60 as the cutoff for acceptable interrater agreement values. Median interrater agreement is .88 for performance, .86 for Structural Research, and .74 for Structural Commercialization, .89 for Contextual Research, and .90 for Contextual Commercialization, suggesting adequate agreement for aggregation. We also generated 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) suggested 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 departments, the ICC(1) is greater than .19 and the F is significant (Bliese, 2000). The ICC(2) values, which are valuable indicators of the reliability of the unit mean, are .54 for all departments, indicating 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

Before proceeding to regression analysis, 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 (including antecedent, Pasteurian orientation, and 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 (including strategic flexibility, balancing commitment, structural research, contextual research, structural commercialization, contextual commercialization, 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 all the variables are well above 0.50, and the construct reliabilities for the factors are also high. Taken together, these results have suggested that the three scales represent concepts that are 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. 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 indicated the importance of the dual capacity. The contexts of strategic flexibility and balancing commitment, and their interaction (university antecedents) are significantly and positively related to the performance variables. As stated earlier that the university antecedents and performance variables are rated by different respondents, these positive correlations are worthy of attention. More importantly, the finding indicated evidence that university antecedents are related to performance. However, our subsequent analysis in the following verified 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 University antecedents, the multiplicative interaction of Strategic adjustment and balancing commitment, would be positively related to Pasteurian orientation. In the model 1, the result show H1 is support. ($\beta = .191$, $p < .05$). Furthermore, as shown in model 2, the relationship between strategic flexibility and Pasteurian orientation are positive but no significant ($\beta = .107$). However, balancing commitment and Pasteurian orientation are positive

significantly. (β = .204, $p < .05$) Hypothesis 2 predicts that Pasteurian orientation, the multiplicative interaction of Knowledge creation orientation and Knowledge utilization orientation, will be positively related to 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/ commercial performance. H2a and H2b are supported. (β = .511, $p < .001$, β = .321, $p < .001$) then, the coefficient for Pasteurian orientation in model 6 is positive and statistically significant (β = .226, $p < .05$). The results of H2a, H2b, and H2c strongly support Hypothesis 2.

Hypothesis 3 predicted 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 (university antecedents) influences the mediator (Pasteurian orientation). This step is supported in model 7 above (β = .194, $p < .10$). The next step is to demonstrate that the independent variable (university antecedents and Pasteurian orientation) influences the dependent variable (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 is in the model, full mediation is indicated, thus *supporting* the full mediation proposed in Hypothesis 3. (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 (β = .264, $t = .004$, $p < .001$) and model 6 (β = .247, $t = .007$, $p < .001$). Interestingly, the control variable, Engineering, is found positive relationship in commercial performance and overall performance.

4.2 Post Hoc Analyses

In Figure 4, this study graphically represents the relationship between Knowledge creation orientation and Knowledge utilization orientation. The result indicted a number of important insights. The majority of departments cluster toward the middle. There is a few departments that rate very high on both orientations—the truly Pasteurian-orientation actors. However, many departments rate below the averages on both dimensions. Additionally, the result indicated 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.

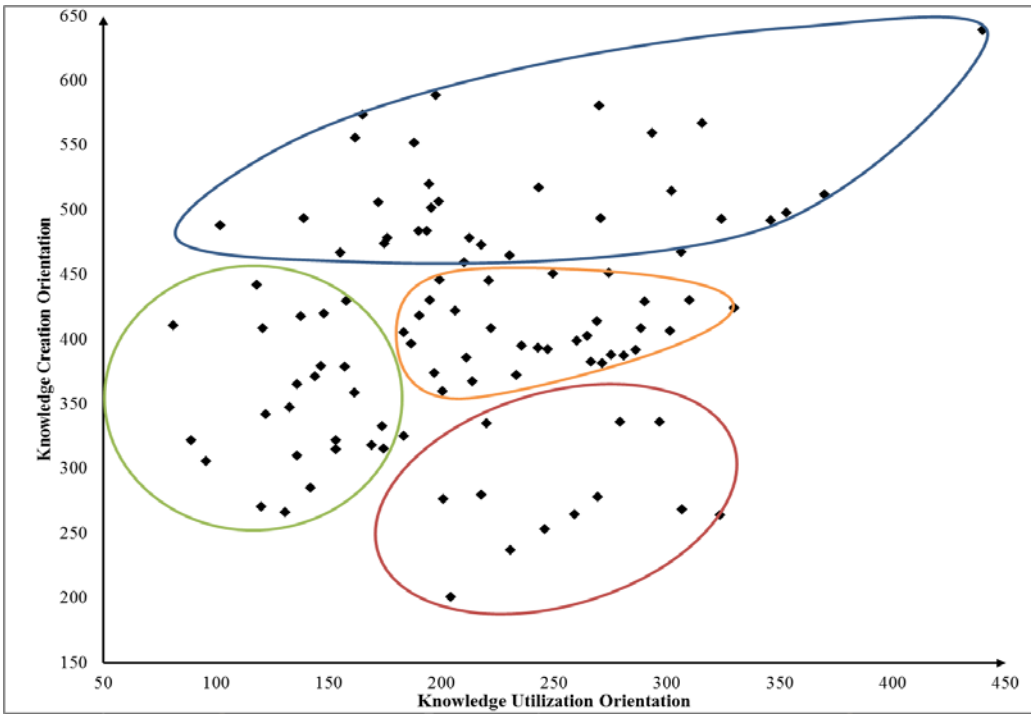

Figure 4 Plot of the Pasteurian orientation for the academic departments

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 provided the best fit. Table 4 indicated the Knowledge creation orientation and Knowledge utilization orientation scores the four cluster centers. Group 1 is consisted of 30 “Pasteurian group” departments, with high ratings on both dimensions. Group 2 is consisted of 12 “Edisonian group” departments, with higher ratings on Knowledge utilization orientation than Knowledge creation orientation. Group 3 is consisted of 31 “Bohrian group” departments, with higher ratings on Knowledge creation orientation than on Knowledge utilization orientation. Finally, Group 4 is consisted of 26 “Socratic group” departments, and is with the below-average ratings on both dimensions.

And, the ANOVA *F*-test is highly significant ($F = 17.35$, $p < .001$). And the discriminate test of Wilks' Lambda value is statistically significant ($p < .001$). These findings indicated that all four groups are different form one another. Pasteurian group is the best performing, followed by 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.

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.Size	21.61	12.28													
2.College	.49	.50	.252*												
3.Engineer	.40	.49	.079	.791**											
4.Medical	.19	.39	-.308**	-.431**	-.401**										
5.Life & Science	.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	120.81	69.33	-.146	-.010	.019	.240*	-.149	.804**	.945**						
9. Knowledge creation orientation	39.40	3.06	-.084	.148	.095	.031	-.216*	.152	.130	.158					
10. Knowledge utilization orientation	30.89	5.56	.126	.511**	.498**	-.211*	-.212*	-.045	.176	.108	.249*				
11. Pasteurian orientation	70.28	6.70	.042	.437**	.409**	-.160	-.238*	.072	.236*	.198*	.682**	.857**			
12.RP	16.68	6.35	.259**	.237*	.127	-.122	-.172	-.236*	-.223*	-.245*	.020	.372**	.234*		
13.CP	216.32	447.70	.113	.367**	.424**	-.182	-.085	-.105	-.084	-.087	-.062	.332**	.180	.222*	
14.OP	4234.3	9790.9	.084	.349**	.399**	-.171	-.099	-.153	-.158	-.152	-.077	.322**	.164	.371**	.939**

[a] N = 99 (departments).

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

Table 3 Result of Regression Analysis[a]

Independent Variables	Model 1: PO (KC*KU) **H1**		Model 2: PO **H1a**		Model 3: PO **H1b**		Model 4: RP **H2a**		Model 5: CP **H2b**		Model 6: Overall Performance **H2c**		Model 7: Overall Performance		Model 8: Overall Performance **H3**	
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)
Engineering	.126	(.418)	.141	(.371)	.128	(.407)	.191	(.158)	.290*	(.038)	.389**	(.005)	.320^{+}	(.051)	.391**	(.005)
Medical	-.061	(.604)	-.039	(.744)	-.048	(.680)	-.133	(.184)	.007	(.946)	-.012	(.902)	.066	(.591)	.002	(.983)
Life Science	-.098	(.362)	-.126	(.248)	-.098	(.361)	.002	(.986)	.117	(.217)	.098	(.306)	.006	(.956)	.092	(.334)
University antecedents	.191*	(.047)											-.194^{+}	(.054)	-.064	(.457)
Strategic flexibility			.107	(.258)												
Balancing commitment					.204*	(.030)										
Knowledge creation orientation							.511***	(.000)								
Knowledge utilization orientation									.321***	(.001)						
Pasteurian orientation											.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.

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

5. Discussion

The findings raise important theoretical and practical issue for discussion. First, the findings suggest that university context as a determinant for departments to nourish PO. Specifically, strategic flexibility and balancing commitment combine as university antecedents that persuade the subordinated departments to simultaneously engage in knowledge creation and utilization activities. This study argues the antecedents of strategic flexibility and balancing commitment are still acting as important signals for departments to redefine their academic routines. This finding supports the view that faculty members' decisions to conduct entrepreneurial involvement are socially conditioned (Shane, 2004a).

Second, there does not seem to be a trade-off between Knowledge creation orientation and Knowledge utilization orientation. In this study, university departments may create a context of encouraging faculty members to make their own decisions as to how they divide their involvement between knowledge creation and Knowledge utilization orientation activities.

Third, even though university antecedents are important to enhance PO and the subsequent performance in Knowledge creation orientation and Knowledge utilization orientation, PO is critical for departments to leverage the impacts of university antecedents on performance.

Then, the PO varies across universities and research fields, suggesting that it is likely a critical capability for many, if not all, universities and research institutions. In our sample, all universities have some departments in Pasteurian group. And University 3 is no one institution in Socratic group. This study argues that institution-specific settings incur substantial impacts on university antecedents.

Moreover, most of the departments in the group of Pasteurian group engaged in the field of engineering research, and comparatively less of them belong to the group of Socratic group. The departments of natural science research fields tend to focus on Knowledge creation and create knowledge utilization around it. The departments of engineering research fields had the highest possibility, while the departments of biological fields had the least, to achieve the capacities of PO.

Table 4 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

For the universities, the workings of academic units, research disciplines, are shaped by several and complex factors, and the ways in which disciplinary departments could contribute to economic and social development vary from area to area. Professional norms, boundaries in knowledge production (Tierney and Holley, 2008), and every disciplines has its own history, and fulfills solve different questions or needs in the society and industry. In other words, some disciplinary departments legitimately operate in Bohr's quadrant, and some operate in Edison's quadrant. However, Stokes's challenge shapes the researches of research disciplines with jointly value at the both (Tushman and O'Reilly, 2007), and that is we call "Pasteurian orientation".

Therefore, accompanying the model of knowledge production change to "Mode2", which emphasize interdisciplinary researches to solve the problems across different disciplines, the research boundaries within the disciplines have become blurred. (Stephens et. al, 2008; Tierney and Holley, 2008) And, inter-discipline makes research disciplines in Bohr's and Edison's quadrants move to Pasteur's quadrant. The researches in Bohr's quadrants get involve in providing basic solution to break the bottleneck of technological development. In the contrast, the researches in Edsion's quadrants need to more basic researches help them to broaden their depth of knowledge. In addition, some research disciplines are be "Pasteurian orientation" because the cost of investment and risk is high, such as biotechnology, genetechnology, etc. Even, some disciplines are Pasteurian orientation naturally because the knowledge production and application accompany the researches done, such as bioengineering, pharmacy, nano-science and so on. (Gómez Uranga et al., 2007)

6. Conclusion

This study verifies positive impacts of developing PO in fostering Knowledge creation orientation and utilization in the academia. Universities are suggested to construct organizational antecedents such as strategic flexibility and balancing commitment in advance. Specifically, universities develop the hybrid structures with one part focused on knowledge creation and another part focused on knowledge utilization, as well as the Pasteurian orientation in the structure suggested above. Subsequently, university departments would take a mid-level position between Knowledge creation orientation and Knowledge utilization orientation as reflected in the Pasteurian orientation in the context construct. Ultimately, departments put in place systems that allow supportive contexts to emerge, in turn shape individual faculty members' behaviors.

The implications for management and policymakers are the followings. The policymakers should be cautious in valuing entrepreneurial performance by incorporating IPR with non-IPR-based approaches. For university presidents, a university is capable to nurture various departments to achieve both knowledge creation and utilization. For technology transfer officers, university contexts which create entrepreneurial culture and novel approaches can facilitate technology transfer. For department heads, PO can be created through structural and

contextual approach to enhance academic entrepreneurship.

This study contributes to realize that university context and university departments act differently in fostering PO that enables faculty members to simultaneously achieve knowledge creation and utilization. PO is acting as an important capability that departments can foster, and that it can be molded at least in part through supportive university context. Unlike the previous studies merely focused on university or faculty member, this study conducted department as the unit of analysis and verified its intermediate role to stimulate academic entrepreneurship. Moreover, the current institutional environments in Taiwan have not persuaded the universities to be pasteurian-oriented in stimulating involvement of spin-off activities. Policy-makers are suggested to re-examine the current policy in evaluating universities and researchers that focus mainly on research publication, patent grant, and technology transfer.

The organizational changes provide the legitimacy to involve the industry for the faculty. (Chreim et al., 2007) In addition, the changes provide the support to sponsor the faculty to engage into the knowledge utilization. (Bramwell and Wolfe, 2008)

In the sum, the disciplinary attributes are endogenous factors to affect the development of PO. And, the organizational contexts influence the activities in the universities internally. The institutional factors influence PO by the policy and academic capitalism. And, organizational factors would determine the operation. Finally, the individual factors demonstrate the willingness of the faculty would influence the implementation of PO.

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