

EDUCATION POLICY ANALYSIS ARCHIVES

A peer-reviewed scholarly journal

Editor: Sherman Dorn

College of Education

University of South Florida

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Volume 13 Number 5

January 18, 2005

ISSN 1068-2341

Patenting Productivity and Intellectual Property Policies at Research I Universities: An Exploratory Comparative Study

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Citation: Mendoza, P. & Berger, J. B. (2005, January 18). Patenting productivity and intellectual property policies at Research I universities: An exploratory comparative study. *Education Policy Analysis Archives*, 13(5). Retrieved [date] from <http://epaa.asu.edu/epaa/v13n5/>.

Abstract

In the 1980s, the US government encouraged the cooperation of industries with universities in order to bridge funding gaps and cope with global competitive markets through legislations that allow universities to start spin-off businesses and to generate profits from patents. At the turn of the century, university partnerships with the private sector have greatly increased through research grants, licensing patents, and in some cases, the formation of new firms—mainly at research universities and in the hard sciences. In response to these entrepreneurial opportunities, university administrators developed intellectual property policies to facilitate the commercialization of research. The purpose of this study is to explore the differences across IP policies among nine research universities as potential sources of influence on faculty engagement in for-profit research ventures according to existing models of faculty role performance and achievement.

Higher education has become increasingly driven to engage in market-oriented behaviors and many of the specific market-oriented activities involve university research partnerships with private industry. This phenomenon, identified as academic capitalism (Slaughter & Leslie, 1997), started in the 1980s as markets became increasingly globalized and funding to postsecondary education continued to decrease as faculty and universities moved towards greater participation in

post-industrial knowledge markets (Slaughter & Leslie, 1997) and as competition for research federal funding became increasingly intensified within the higher education arena (Newman & Courtier, 2001). At the same time, the US government encouraged the cooperation of industries with universities in order to bridge funding gaps and cope with global competitive markets by introducing a number of laws to allow universities to participate in profit making and the development of products competitive in the global market (Altbach, 1999; Slaughter & Leslie, 1997). These federal initiatives were largely a consequence of Reagan's economic policy of open markets and less government intervention, which resulted in less federal support to federal agencies and more privatization (Altbach, 1999).

The Bayh-Dole Act in 1980 was the first legislation that allowed universities to start spin-off businesses and to generate profits from patents (Campbell & Slaughter, 1999). As a result, university partnerships with the private sector have greatly increased through research grants, licensing patents, and in some cases, the formation of new firms—mainly at research universities and in the hard sciences. In response to these entrepreneurial opportunities, university administrators have established intellectual property (IP) policies to facilitate the commercialization of research (Olivas, 1992). IP is defined as inventions, discoveries, procedures, know-how, and artistic productions; examples include computer software, chemical or biological procedures, and electronic or mechanical devices. Little knowledge has been empirically documented regarding how well the wide variety of IP policies actually accomplishes the intended goals of university agents. Therefore, the purpose of this study is to explore differences across IP policies among nine research universities as potential sources of influence on faculty engagement in for-profit research ventures.

From 1980 to 1995, research and development (R&D) federal support at universities and colleges increased by 51 percent however, due to the Bayh-Dole Act, industry support research increased by 203.8 percent (Gladieux & King, 1999). These types of activities have increased material resources streams for research-oriented postsecondary institutions. In addition, commercialization of research through patents has also been a source of professional prestige as an important symbolic resource for participating universities. Therefore, private commercial partnerships and ventures have become both a symbol of prestige and a source of material funding for research universities (Slaughter, Campbell, Hollernan, & Morgan, 2002). Currently, research universities are developing a culture in which external fund-raising is an ongoing responsibility:

In most other states with first-class research universities, they figured out back some time in the '80s, if not before, that the states would do what they could do, but it wouldn't be enough to support competitive excellence and that the institutions themselves had to take ownership of their own revenue stream. They had to raise money, and they had to commercialize their intellectual property, and they had to push their grants and contracts to the outside limit, and they had to make relationships with industry and business, and they had to make their auxiliary enterprises at least break even if not profitable, and so on (Buchholz 2002, p. A1).

The preceding quote reflects the degree to which academic capitalism as the engagement in market-like behaviors on the part of faculty and universities has become a dominant force within higher education in general and an even a stronger trend among research universities (Slaughter & Leslie, 1997).

Academic capitalism has also been fostered by significant changes in the nature of scientific research due to the development of new fields, techniques and projects involving hundreds of

researchers and millions of dollars—a phenomenon that has been dubbed "big science" (Zusman, 1999). For example, prior to fundamental breakthroughs in molecular biology and genetics, life scientists in universities were mainly conducting basic research and industrial laboratories were at the forefront of applied research. The new developments in these fields combined with academy-industries partnerships have given rise to an emerging biotechnology industry hosted mainly in research universities where academics in these fields have become part of a larger technological community involved in commercial activities (Powell & Owen-Smith, 2002).

After the inception of the Bayh-Dole Act, university-based research with close ties to industry nearly doubled between 1980 and 1990 (Zusman, 1999) and by the 1990s, there were roughly 1,000 university-industry research centers at more than 200 U.S. universities. At the turn of the new century, the number of universities involved in commercial ventures has increased eightfold and the number of university patents has increased fourfold (Slaughter et al. 2002). Moreover, some of the traditional non-profit institutions have created for-profit subsidiaries or partnered with for-profit firms and adopted other forms of commercialization by outsourcing and through high executive salaries (Newman & Courtier, 2001).

However, academic capitalism is not a uniform phenomenon across higher education institutions. The unevenness is primarily due to unequal distribution of research and development (R&D) funds among universities. Zusman (1999) reported that the top 50 research universities in 1995 accounted for 60 percent of the R&D academic expenses and the top 100 for the 80 percent. The distribution of funds across disciplines has been stable over the last two decades although uneven as well. For example, faculty in engineering receive 79 percent of university-industry funding (Zusman, 1999) whereas around 54 percent of federal funds go to life sciences, 16 percent to engineering, 11 percent to physical sciences, and only 6 percent to social sciences and humanities (Gumport, 1999).

As faculty engage in research with commercial potential and as the number of partnerships academia-industry grows, university administrators have invested a significant amount of resources in appropriate infrastructure to promote commercialization of research as a means to generate revenues through royalties and licenses (Olivas, 1992). However, there are difficulties in having contractual arrangements and IP policies that accommodate the differing needs of industry, individual faculty members, and university campuses when the three parties have different objectives and cultures (Hum, 2000). For instance, faculty have usually conducted basic research for non-commercial reasons and their rewards system is based on priority of discovery and prestige rather than material stock options or royalties. Conversely, industry representatives are motivated by profits as well as the challenges of product development and market risk (Slaughter & Leslie, 1997).

Other issues fostered by faculty partnerships with industry representatives include conflict of interests, restriction of information flow, shift power to non-academic personnel, universities' fragmentation into entrepreneurial fiefdoms, shifts of research priorities toward more marketable areas with the consequent distortion of traditional academic missions as well as both positive and negative impacts on graduate education (Campbell & Slaughter, 1999; Gumport, 1999; Powell & Owen-Smith, 2002; Slaughter & Leslie, 1997; Slaughter et al., 2002; Zusman, 1999). In addition, as research universities compete against each other for federal funding, annual giving, earnings on endowment state agencies, internal savings, and other surplus-generating activities such as returns on patents and licenses, administrators try to promote these partnerships by controlling faculty research more than a decade ago and by offering external rewards to faculty such as wages and distribution of royalties (Hum, 2000).

In sum, industry-university partnerships have provided university administrators, faculty members, and businesspersons with new relationships that are changing the nature of academic roles

and rewards (Campbell & Slaughter, 1999). These professional shifts have had a variety of impacts on higher education; some—have been viewed quite positively—such as the generation of new sources of revenue noted above—while others are concerned that other unintended consequences may be having a negative impact on the academic profession. The understanding of these shifts and their consequences is a relatively new area of study that provides a unique opportunity to investigate the reshaping of professional roles as well as the tensions and conflicts that surround such changes (Campbell & Slaughter, 1999).

This exploratory study is designed to increase existing knowledge about the impact of IP policies on the promotion of commercial research activity within postsecondary institutions. More specifically, this study analyzes the relationship between IP policies at nine public Research I universities with levels of faculty engagement with entrepreneurship. In addition, this study uses the findings from this analysis to provide recommendations for increasing patenting levels at public Research I universities.

Theoretical Framework

The American professoriate is shaped simultaneously by the social, political and economic contexts of academic capitalism mainly in research universities and in those disciplines most closely aligned with the market (Campbell & Slaughter, 1999; Etzkowitz & Leydesdorff, 1997; Powell & Owen-Smith, 2002; Seashore, Blumenthal, Gluck, Soto, & Wise, 1986). After reviewing existing literature on academic capitalism, we identified two major areas in which academic capitalism has influenced the academic profession in terms of faculty motivation to participate in partnerships with the private sector in Research I universities and primarily in the hard sciences. These two main areas of influence are (1) faculty motivation and academic rewards systems and (2) administrative control over the faculty profession. In this section, we review previous empirical results regarding these two areas and develop a conceptual framework for this study.

Faculty Motivation and Academic Rewards Systems

Seashore et al. (1989) conducted the first research on faculty attitudes towards partnerships with the private sector. Based on two surveys with 778 life scientists and administrators from a sample of 30 major research universities, Seashore et al. found that the major factors that determine faculty interest towards relationships with industry include past success as measured by research publications, degree of establishment that faculty may have such as having more to sell, less motivated by traditional academic rewards, and having greater financial interests. However, based on the finding of Agrawal and Henderson (2002) study, faculty involved in commercialization of research are a minority, even in institutions heavily involved with academic capitalism such as The Massachusetts Institute of Technology (MIT), which holds most of the patents filed by American universities. Moreover, most of the MIT faculty surveyed by Agrawal and Henderson estimated that their patents account for less than 10 percent of the knowledge transferred from their labs and nearly half of the surveyed faculty have never patented, in contrast to 60 percent of the faculty that publish in any given year.

The findings above are consistent with existing knowledge about faculty motivation in general (e.g. Bellas & Toutkoushian, 1999). More specifically, studies on faculty attitudes towards commercialization of research suggest that rewards are an important influence in faculty activity and that publishing research in peer reviewed journals is the recognized norm for academic achievement under traditional rewards structures (e.g. Hum, 2002; Kirk, 2002; Powell & Owen-Smith, 2002; Seashore et al., 1989; Slaughter & Leslie, 1997). In fact, Agrawal and Henderson (2002) explain their

result by observing that publishing academic papers as well as conducting basic research are far more rewarding and important activities for most faculty than patenting. However, for private sponsors, secrecy of new knowledge, rather than broad dissemination, is essential for their survival in the competitive market of patents. Therefore, the secrecy demanded by private sponsors on faculty works is in contradiction with traditional academic values regarding knowledge dissemination (Merton, 1975).

Other studies of faculty show that internal motivations such as desire for recognition, science contribution, need for professional freedom, and development of their capabilities are stronger than external motivations such as monetary incentives, unless those monetary rewards allow them to do more research (Campbell & Slaughter 1999; Hum, 2000; Peltz & Andrews, 1976; Slaughter & Leslie, 1997; Slaughter et al., 2002). Slaughter et al. (2002) found that faculty prefer to engage in basic research over commercial endeavors because symbolic rewards have been institutionalized to be more highly valued than have more materially-oriented rewards such as stock options or royalties that are awarded for accomplishment of commercial research efforts. In contrast, industry rewards are pecuniary and patents are the coin of the realm in the world of commercial science (Slaughter & Leslie, 1997). According to these empirical studies, internal motivations and rewards structures and values are areas where most of the differences between industry and academic cultures exist. The academic profession is abundant in resources of intrinsic motivation that supercede monetary incentives such as fascination of research, the enchantments of teaching, peer recognition, and prestige (Clark, 1997).

The role of internal motivations and rewards structures in faculty behavior can be better understood through a framework of faculty role performance and achievement developed by Blackburn and Lawrence (1995), which integrates research on faculty role performance and productivity with motivation theories. The following paragraphs are dedicated to a description of the main aspects of this framework and how it applies to faculty behavior in light of academic capitalism as it has been documented in previous empirical studies.

The Blackburn and Lawrence (1995) framework models immediate and future faculty productivity as the result of interactions between faculty members as individuals and their work environment. As the basis for this model, they classify existing motivation theories into two main groups, non-cognitive and cognitive. Non-cognitive theories of motivation are based under the assumption that little or non-human cognition is required and that internal needs, personality dispositions, and external incentives and rewards affect individuals' behavior in predictable ways. Cognitive theories of motivation assume that people make decisions about their behaviors by evaluating their capacity to respond and by estimating their possible losses and gains. The properties of individuals used in this model are:

1. Socio-demographic: including age, gender, race, ethnicity, and country of origin.
2. Self-knowledge: including self-image, self-assessed competence and sense of self-efficacy as well as personal attributes, skills, internal needs, values, and dispositions.
3. Career: including graduate socialization experiences, academic discipline, type of institution, positions held, career age and experience, and past accomplishments.
4. Social knowledge: including how faculty perceive their work environment including individuals' understanding of others' expectations, views, and values.

On the other hand, the properties of the work environment that affect behavior are:

1. Environmental conditions: including structural and normative features of the institution such as fiscal well-being, geographical location, governance structures, policies, mission, facilities, and resources.

2. Environmental responses: including the various forms of formal feedback that faculty receive about their performance such as tenure reviews and students' evaluations
3. Social contingencies: including events that happen at a personal level such as childbirth and marriage.

According to empirical studies on faculty entrepreneurship, this study applies the Blackburn and Lawrence (1995) framework by associating relevant environmental and individual properties relevant to faculty patenting productivity into the different components of their framework. Figure 1 is an adaptation of the Blackburn and Lawrence framework representing the components of their model and how they relate to faculty patenting productivity. The thickness of the arrows represents the intensity of the influence from one component to another.

Faculty productivity is defined in this study as the number of faculty patents facilitated by faculty engagement with entrepreneurship. The salient environmental conditions that have fostered entrepreneurship in higher education include the shrinking federal research funding as well as the legislations by the federal government in order to promote academic entrepreneurship and industry-academy partnerships. A subsequent environmental response to these conditions is manifested in an enduring competition in higher education for research funds, which brings prestige to those institutions and faculty that successfully acquire such funds. In addition, universities have responded to these environmental conditions by developing IP policies to facilitate the commercialization of research. These policies have induced greater control over the faculty profession and monetary rewards to faculty in the form of funds for research, salary increases, and royalties from technology transfers. The environmental conditions and responses brought by academic capitalism have influenced the social knowledge of faculty in departments involved in academic capitalism especially in regards to shared values and expectations. However, the environmental responses are more directly related to the faculty profession and thus, they have a greater influence on social knowledge of faculty than do environmental conditions. According to Blackburn and Lawrence (1995) framework, productivity influences environmental responses. Therefore, patenting productivity should influence competition for research funding as well as IP policies.

Empirical evidence indicates that faculty in departments that are significantly involved with academic capitalism are receiving mixed messages regarding values and expectations of their work environment (Slaughter & Leslie, 1997). This tension inhibits faculty from fully engaging in entrepreneurial behavior, which results in low patenting productivity. These mix messages are due to traditional academic values in opposition to business-oriented values brought by academic capitalism. For example, academic freedom, self-governance, peer recognition, publication of findings, and internal motivations and rewards are in opposition to secrecy of knowledge, control over the faculty profession by administrators, and monetary incentives.

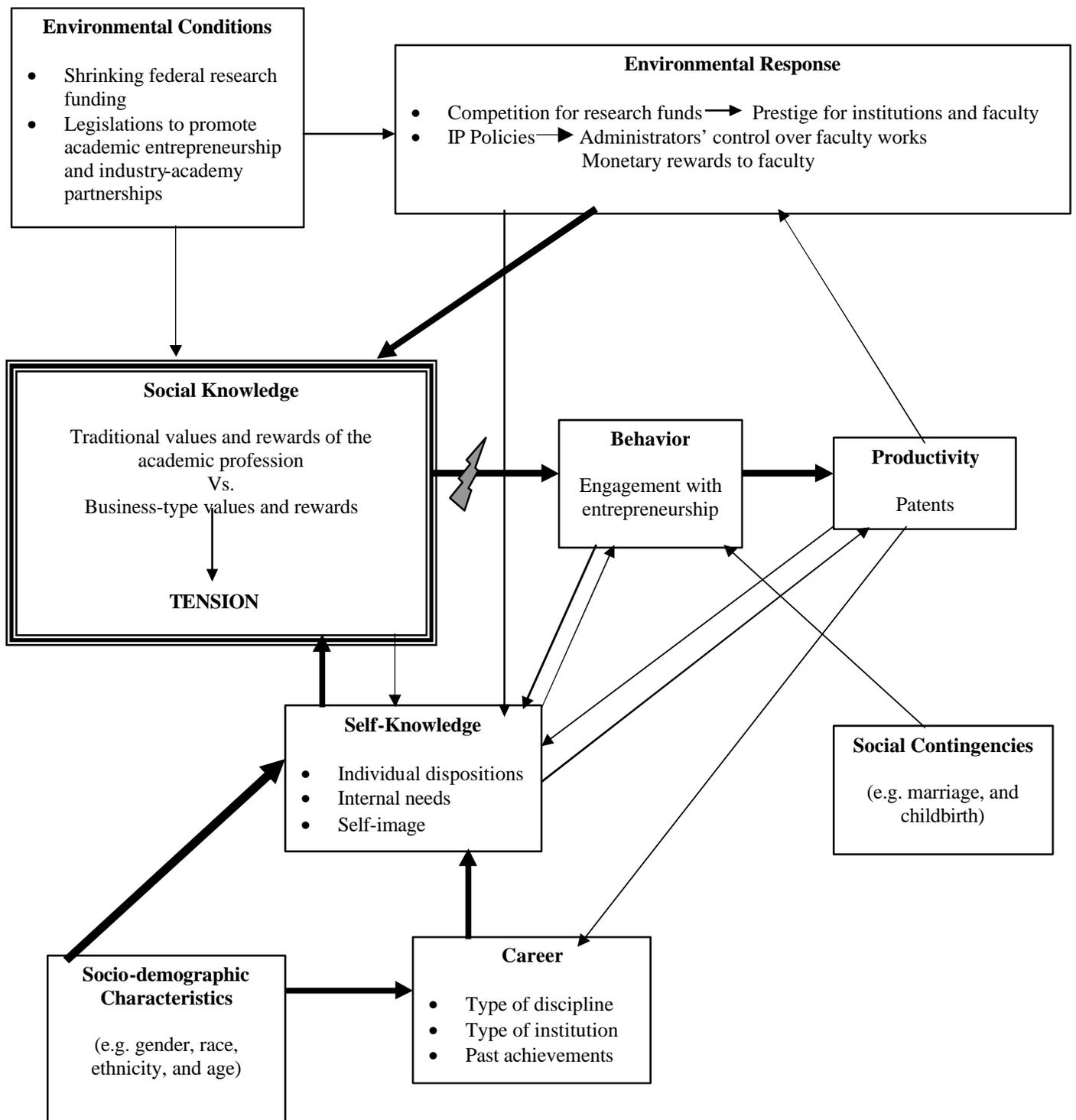


Figure 1. Conceptual framework for understanding faculty patenting productivity (based on the Blackburn and Lawrence (1995) framework of faculty role performance and achievement)

Blackburn and Lawrence (1995) emphasizes the influence of individual characteristics on faculty social knowledge, behavior, and productivity. This is consistent with Seashore et al.'s (1989) work, which is one of the few studies that found individual characteristics related to self-knowledge (such as individual dispositions, internal needs and self-image) that might affect faculty entrepreneurship. Seashore et al. find that some faculty have greater disposition to monetary incentives than others and other studies regarding the influence of internal motivations in faculty behavior (Campbell & Slaughter 1999; Hum, 2000; Peltz & Andrews, 1976; Slaughter & Leslie, 1997; Slaughter et al., 2002). Nonetheless, more research in these areas is needed in order to better understand other findings such as Agrawal and Henderson's (2002) identification of differences in the level of engagement with entrepreneurship among faculty members with different individual self-knowledge characteristics.

Staw (1983) developed a model to explain faculty motivation by using models and research from organizational behavior with emphasis on motivation theories that might provide useful insights for future research on the influence of self-knowledge characteristics on faculty entrepreneurship. According to Staw, much of faculty behavior is voluntary in nature, self-governed and sustained by intrinsic outcomes. However, as universities experience a shortage of resources, faculty might begin to seek these externally administered rewards because as universities' resource allocation shrinks, the value of universities' external rewards for faculty increases, even to the extent of becoming a primary indicator of personal achievement. This model offers an individualistic perspective to faculty behavior in light of external rewards and might help to explain the findings from previous research indicating that academic partnerships with industry are not likely to satisfy some fundamental traditional forms of faculty rewards.

The career construct as an individual characteristic in the Blackburn and Lawrence (1995) framework has a significant influence on self-knowledge and is moderately influenced by productivity. This construct clearly affects faculty engagement with academic capitalism because on the one hand, type of discipline and institution are key elements in faculty patenting productivity given that it is a phenomenon occurring mainly at Research I universities and in applied fields closely aligned with the market. Moreover, according to Seashore et al. (1989), degree of career establishment is also influences the entrepreneurial behavior of faculty.

The Blackburn and Lawrence (1995) framework considers socio-demographic characteristics as the strongest influence on faculty productivity given its significant impact on self-knowledge. Socio-demographic characteristics also influence significantly career. However, little research has been conducted on the impact of socio-demographic characteristics constructs on faculty entrepreneurship, which suggests a promising area for future research. Finally, the last component of the Blackburn and Lawrence model refers to social contingencies such as marriage, childbirths or death that influence individuals' behavior in any organization.

The Blackburn and Lawrence (1995) framework is helpful for understanding the factors involved in faculty patenting productivity. Based on this framework and previous research, this study focuses on the tension generated in faculty self-knowledge by the incompatible rewards systems and values brought by industry and academics in environments involved in academic capitalism and how these mixed messages might affect faculty patenting productivity.

Administrative Control over the Faculty Profession

Campbell and Slaughter (1999) conducted a study based on questionnaires mailed to 127 administrators and 280 faculty across disciplines from 86 Carnegie institutions and found that one of the major points of tension between faculty and administrators as a consequence of

commercialization of research is administrators' willingness to control resources and relationships generated by faculty-industry partnerships. University administrators seek control over faculty research with commercial potential in order to patent and license it to industrial partners. Similarly, other authors have stressed the fact that faculty involved in research with commercial potential and subject to contractual obligations with industry representatives lose control over their IP and autonomy over their professional lives given the secrecy demanded by corporations as well as the timelines and specific research results demanded by sponsors (Kirk, 2000; Scott 1998). However, managing faculty cannot be as direct as it is with industry employees, whose behavior is non-voluntary and driven directly by established organizational outcomes. For example, faculty might not be always interested in the same institutional outcomes that administrators want, and when administrators attempt to impose certain behaviors on faculty they must often first consult with some form of faculty self-governance.

In the academic world, administrative control has traditionally been limited by the significant influence of peer professional groups, which provide symbolic rewards and professional mobility. Thus, Staw (1983) suggests heavy-handed control of faculty behavior as a way to diminish faculty self-governance and self-motivation. However, this approach will negate the primary strengths of universities and higher education will become more of a corporate industry. An intermediate path proposed by Staw would be for administrators to become facilitators rather than controllers who provide an environment that best meets the intrinsic interests of faculty. According to the Blackburn and Lawrence (1995) framework, this approach would diminish the tension originated in the social-knowledge construct of their model due to incompatible values and rewards between industry and academics as faculty values of self-governance and independence are not significantly oppressed.

Nevertheless, limited budgets and scarce resources tend to move administrators away from the role of facilitators towards the role of an enforcer of priorities (Staw, 1983). This struggle for control over faculty profession and products can be explained by resource dependency theory, which suggests that organizations and units within organizations engaged in an enduring competition over scarce resources and thus, conflicts and struggles to obtain these resources are an ongoing part of organizational life (Pfeffer, 1994). Following this argument, industrial partnerships constitute a critical resource for university administrators necessary to sustain external revenues and prestige given the current political and economical arena of globalization and privatization (Campbell & Slaughter, 1999). However, university administrators' drive to increase external funding for research through faculty-industry partnerships produces struggles of control over the faculty profession (Slaughter & Leslie, 1997). This control is often in direct opposition with the fundamental value of academic freedom. As a result, administrators' interest in profits and competition are increasingly entering occupations and fields historically controlled by the faculty profession, which challenges faculty monopolies of practice and the authority of faculty as experts. Thus, conflicts of interests between academics and administrators result as their respective monopolies aim to control each other. In sum, administrators are challenged to act in ways that could channel faculty behavior towards a desired institutional outcome without, at the same time, suppressing faculty intrinsic interests and academic values.

To synthesize, 1) The traditional role of faculty is the one of creativity and discovery, and academic freedom and individualism are indispensable for such an aim. Moreover, the academic profession has traditional values rich on intrinsic rewards and recognition in opposition to business-oriented values and rewards brought by industry sponsors. Therefore, if higher education continues to engage in academic capitalism, a delicate balance between the traditional values and rewards of the academic profession and the ones brought by faculty-industry partnerships should be achieved in order to best maximize the benefits and satisfaction for both faculty and administrators on

university campuses engaged with academic capitalism; 2) University administrators are seeking sources of revenues and prestige through partnerships with industry, which result in an increase of administrators' control over the faculty profession and thus, tensions between faculty and administrators are likely to occur.

Based on the framework developed, this study is designed to analyze the IP policies at nine Research I universities in order to explore which types of policies appear to be most closely related to higher levels of patent productivity as an important intended outcome of commercial research ventures in higher education. The findings from this analysis are then discussed in relation to the theoretical framework as the basis for policy recommendations that can be used by leaders at Research I universities.

Methods

An exploratory comparative analysis among peer Research I universities' IP policies in relation to their patenting productivity provides insights regarding which aspects of the IP policies might motivate faculty to engage with entrepreneurship according to the theoretical framework on faculty productivity. Given the wide variety of Research I universities, a comparative analysis needs to be conducted among universities with similar levels of performance that might affect patenting levels. Therefore, the first stage of this study consisted of the determination of peer universities by using the top 50 research universities as they were ranked by Lombardi, Craig, Capaldi, Gater, and Mendonca (2001) with similar parameters of performance regarding patenting productivity. The second stage consisted of a comparative analysis of the IP policies of the universities selected in the first stage guided by the framework developed. The following sections describe the two methodological stages used in this study.

Determination of Peer Universities

The initial purpose of this study was to identify peer universities for comparison with one particular public research university (coded university A) in order to identify aspects of the IP policies that might facilitate or inhibit patenting activity. As mentioned above, the determination of the peer universities in relation to University A was based on a cross-sectional sampling of research universities in the nation from the top 50 research universities ranked by Lombardi, et al. (2001). In their report, universities were ranked at a campus level according to nine measures including investment in total and federal research, endowment assets, annual giving, postdoctoral appointees, doctorates granted, faculty members of the National Academy, faculty awards, and median SAT score for the years 1999 and 2000. This ranking method consisted of counting how many times each research institution ranked in the top 25 on each of these nine measures. A similar methodology was used to produce a second set of institutions ranked 26 through 50.

Eight peer universities were identified for University A through a two-step process. The first step consisted of drawing four sets (Set 1-Set 4) from Lombardi et al.'s top-50 research universities (2001) as follows: The first two sets included all of the top-50 research universities where Set 1 had absolute values for the nine measures used at Lombardi's ranking and Set 2 had normalized values by the number of doctorates granted in the year 1999. Sets 3 and 4 were drawn from the top-50 by choosing the five universities ranking above and the five universities ranking below University A at each of these nine measures. As in Set 1 and Set 2, Set 3 and Set 4 had absolute values and normalized values by the number of doctorates granted respectively. Both absolute and normalized values were used in order to control for size at each university.

In the second step, an utility function (Clemen, 1952) was applied to each university of these four different sets drawn in the first step. This utility function provides information on how similar a given university is to University A according to the nine measures used to generate the Lombardi et al.'s (2001) ranking. Once the utility function was applied, the universities that were closer in terms of similarity to University A in Sets 1 to 4 simultaneously were selected. Finally, only public institutions without a medical school (like University A) were chosen and considered peers of University A.

The Utility Function

Mathematically, the utility function is denoted as m^i , where i is an index that identifies each university from the four sets drawn in the first step. This utility function determines how close to University A the other universities are according to the relevance of the nine parameters used by Lombardi et al. (2001) to patenting levels. Mathematically, a comparatively small value of the utility function (m^i) of a given university means that this university and University A are similar in terms of the nine parameters weighted as predictors of patenting levels.

Each of the nine parameters per university are represented by the variable x_j^i where j identifies each of these parameters. For example, if the parameters are coded from 1 to 9 and the universities at each set are numbered, x_5^{10} is the parameter number five of the university number ten from a given set. Similarly, x_j^u corresponds to the value of University A at the parameter number j . According to this notation, the utility function for each university \ at each set was defined as:

$$m^i = \sum_{j=1}^9 m_j^i = \sum_{j=1}^9 (x_j^u - x_j^i)^2 * W_j$$

W_j is a weight assigned to each of the parameters based on a qualitative assessment of the degree of relevance of each measure to patenting levels. The numerical values of the weights for each parameter were assigned qualitatively (Table 1) based on a scale from zero to 100 depending on how these parameters are expected to determine the amount of patenting at each university. In general, financial parameters were considered as primary predictors of patenting levels because the nature of the research in fields that are likely to generate patentable outcomes is expensive and requires significant amounts of funding.

Following this line of argument, total research expenditures were considered most influential on patenting levels over total federal research expenditures because total research expenditures includes funds from private sponsors. However, federal research funds are also strong predictors of patenting levels given that the Bayh-Dole Act allows commercialization of research funded by federal funds. The number of postdoctoral appointees and doctorates granted were considered as third and fourth in relevance to patenting levels after financial incentives research because these members of the research community are considered valuable skill research workforce (Slaughter et al., 2002). Endowment awards were placed fifth given that although they usually provide basic infrastructure for research, endowments are not directly involved in the generation of products with commercial value. Sixth and seventh places were assigned to number of faculty awards and members of the national academy respectively as measures of the quality of scholars at each university. Finally, annual giving was placed in eighth place because it contributes to research productivity and patenting although in a lesser degree than the seventh measures above it. The ninth measure, median SAT score, is a measure of undergraduate education and thus, it was given no weight at all given its irrelevance to patenting levels.

Table 1
Criteria used for defining weighted parameters of
the utility function used to define peer institutions

Parameter	Points
1999 Total Research	100
1999 Federal Research	80
1999 Postdoctoral Appointees	60
2000 Doctorates Granted	50*
2000 Endowment Assets	30
2000 Faculty Awards	25
2000 National Academy,	25
2000 Annual Giving,	20
1999 Median SAT Score	0

*or 0 when used for normalizing in Set 2 and Set 4

Intellectual Property Policies Analysis

The policy analysis was conducted in three stages: The first stage consisted of a content analysis to identify major overlapping sections within the policy guidelines for each of the nine universities being investigated in this study. The second stage was based on the results of the content analysis and focused on identifying the sections that might influence patenting levels at these universities. Finally, the third stage was based on a comparative analysis of the sections identified in the second stage and the levels at patenting across the nine universities. As a result of the comparative analysis, each university was qualitatively ranked in descendent order according to the relative intensity of each section identified in stage two and patenting levels.. Patenting levels were defined as the number of patents issued as of August of 2002 over the average amount of R&D dollars expended during the years from 1998 to 2000. Given that patents usually take up to two years to be issued since filed, we used a two-year funding up to the year 2000 and number of patents up to the year 2002.

Control over faculty profession by administrators as well as rewards structures and values were the two key factors identified in previous empirical studies and used to develop the theoretical framework. Thus, the sections in the IP policies identified through the content analysis as measures

of rewards to inventors as a result of commercialization of research were the provisions regarding to the distribution of royalties to inventors and to their research unit. The sections related to administrators' control over faculty academic works chosen were the ones related to ownership of IP, disclosure of inventions, administration of the policy, and the degree of flexibility of the policy. The provision regarding ownership of IP determines the circumstances in which faculty own their work. Disclosure of inventions to administrative officials determines under which circumstances faculty must disclose their research. Administration of the policy refers to the type of administrative structure that makes decisions regarding IP issues. For example, a policy might determine that decisions are made by a committee mainly composed by faculty or such decisions are made by one or two administrators. Degree of flexibility of the IP policy refers to the policy's basic structure between a general guideline where decisions are made on a case-by-case basis or a detailed policy that include provisions in an attempt to cover all possible cases.

Results

The universities in this study were coded UA for University A and UB, UC, UD, UE, UH, UI, UJ, and UK for the eight peer universities of UA. In addition, the universities were classified into four groups according to their patenting levels, which are low, moderate, high and highest. Figure 2 represents the patenting levels of all the institutions used in this study. The group with highest patenting levels has only one university (UB), given that it's patenting level is much higher than the other institutions in this study. Similarly, the group with lowest patenting levels has only one university (UK) because its patenting level is much lower than the rest. The group with high patenting levels is composed by UC, UD, and UE and the group with moderate patenting levels include UA, UH, UI and UJ. The results of the comparative IP policies analysis are represented in Figure 3.

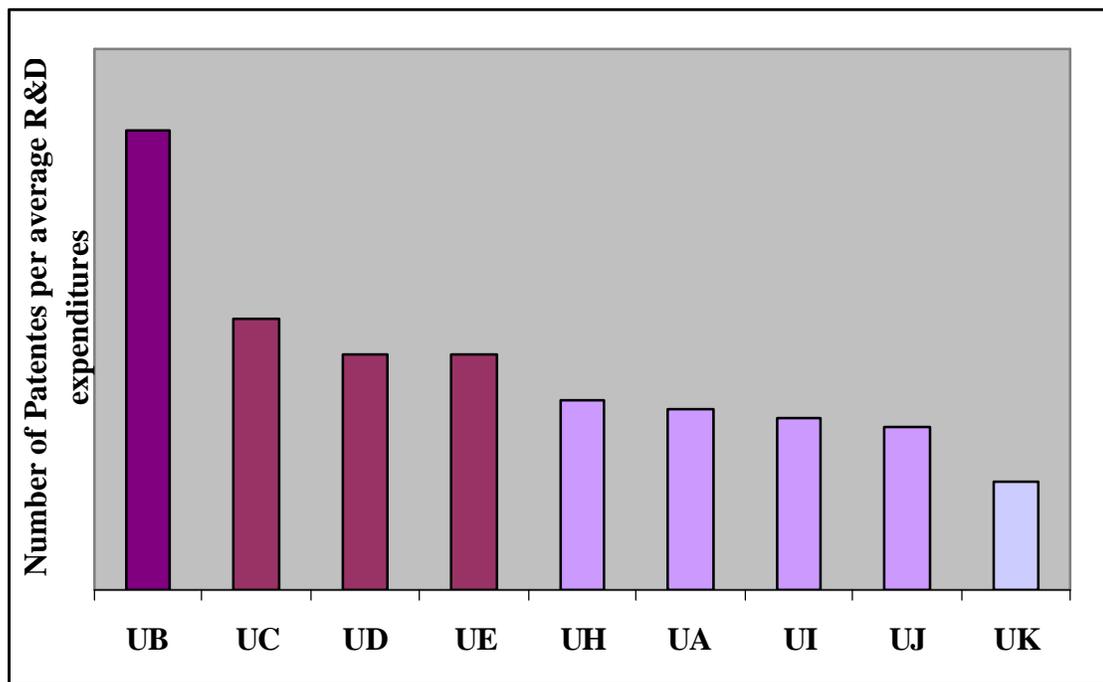


Figure 2. Patenting productivity levels of nine Research I Universities

Highest patenting levels group (UB)

UB exerts the highest control over faculty profession and it is the second most generous in royalties to inventors' research unit after UD, although interestingly, these two universities are fourth and seventh respectively in distribution of royalties to inventors. Based on the policies analyzed, some of the measures used to exert tight control include mandatory disclosure of all inventions regardless of their nature and commercial potential, ownership by the university of all IP regardless of the amount of use of university's resources as well as the inclusion of specific provisions in the IP policy regarding ownership of software, distance learning materials, lab notes, and all types of research data as well as specific provisions regarding proper archiving of lab and research notes of inventions.

High patenting levels group (UC, UD and UE)

UD and UE have a similar policy of relative generosity to faculty, although UD is the most generous with the inventors' research unit whereas UE is more generous with inventors directly. In both cases, these universities exert significant control over faculty profession, although UD controls more in general. UC, which is the leader in patenting levels of this group, has the second most generous policy in terms of overall rewards to inventors and is third in revenues to the inventors' research unit. Interestingly, UC policy emphasizes flexibility given that almost all the decisions are made by a committee of mainly faculty and in a case-by-case basis. Thus, UC policy appears to be very democratic, flexible and generous in terms of royalties to inventors. This model, based on a flexible and democratic policy may be effective in terms of patenting levels, given UC's second place overall in patenting levels after UB, which contrary to UC has a policy of exerting tight control over faculty profession. According to the theoretical framework, this result suggests that UC is exerting minimum control over faculty profession, which in return creates fewer tensions between faculty and administrators and more faculty willingness to engage in for-profit venues due to the generous material rewards of this university to inventors and their research unit.

Moderate patenting levels group (UH, UA, UI and UJ)

These universities are mainly characterized by having a moderate policy in terms of rewards and vague in terms of control over faculty profession compared to the two groups above them. The policies of this group are considered moderate because they are not as generous in terms of royalties compared to their peer universities in the two groups above them and vague because they do not have a clear policy of either tight or loose control over faculty works. In other words, the IP policies of this group are inconsistent in terms of degree of control across the variables regarding control over faculty profession. UH, the leader in patenting levels of this group, has a policy that is similar but more vague and moderate to UC's policy. On the one hand, UH is third in one of the control parameters and last in the other two, which suggests that UH has a policy of minimum control over faculty profession similar to UC's, but to a lesser degree. On the other hand, UH is sixth in rewards to inventors' research unit but it is second in rewards to inventors. Finally, UA, UI and UJ have lower levels of rewards to both inventors and inventors' research unit and a more vague policy of control than UH.

Low patenting levels group (UK)

UK has the lowest levels of rewards to inventors and their research unit and a vague policy of control over faculty profession given that its policy is comparatively strong in some sections and weak in some others regarding control over faculty profession.

In synthesis, the universities with IP policies that exert the highest control over faculty profession and are the most generous in the distribution of royalties to the inventors' research unit have the first and third levels of patenting—UB and UD. UC is the most generous in royalties to inventors and the least controlling of faculty profession and has the second highest level of patenting. The universities that are vague in their control policy and moderate in royalties to inventors and their research unit constitute the third group in patenting levels. Finally, the lowest group constituted by UK has also a vague policy in terms of control over faculty profession and offer the least amount of royalties to inventors and their research unit.

Discussion

The results of this study indicate that in the case of the universities studied, material rewards to faculty, especially rewards to the research unit of the inventor, may exert a significant influence on patenting productivity in instances where tight control over faculty profession is also in place. However, the remarkable exception of UC's policy, which is the most flexible, mainly governed by faculty, and generous in terms of total royalties to both inventors and inventors' research unit, opens the question of whether tight control over faculty profession by administrators is necessary in order to achieve high levels of patenting productivity.

Although the size of the sample in this study was small and therefore generalization to the population of Research I universities is limited, these results support the theoretical framework developed for this study. On the one hand, tight control over faculty profession, if balanced with a policy of generous material rewards to faculty research unit seems to return high patenting levels. According to Stew (1983), although tight control still generates tension in the social knowledge of faculty members, monetary incentives in times of budgetary constraints become a valuable reward that brings personal satisfaction to faculty and thus, balances such a tension. Moreover, monetary rewards that allow faculty to continue pursuing research satisfy intrinsic motivations of the academic profession such as the fascination for research and prestige (Clark, 1997). In this case, material rewards are transformed into symbolic rewards brought by the scholarship of research.

On the other hand, if the control over faculty profession is low, as it is in the case of UC, monetary rewards directly to the inventor seem to be an effective incentive. According to the theoretical framework, if academic fundamental values are not threatened, then the tension due to conflictive messages of values and rewards in the social knowledge of faculty diminishes. Therefore, faculty are more likely to engage with entrepreneurship given the external monetary rewards and prestige that these activities offer.

In sum, by following the theoretical framework developed for this study and supported by the findings from the comparative analysis conducted, it appears that universities should have a clear policy of either tight or loose control over the faculty profession as well as generous monetary rewards to inventors and the inventors' research unit. However, if tight control is chosen as the predominant policy, it is important to compensate such control through generous rewards to inventors' research unit. If moderate control is preferred, then the policy should perhaps be generous with inventors directly. In general, it appears that IP policies that aim to achieve an

optimal balance between control over faculty profession and academic rewards structures are most likely to generate higher levels of patenting levels.

This exploratory study has illuminated ways in which university administrators could improve the patenting levels on their campuses through IP policies. However, much research is needed in order to understand the interplay between faculty motivations and administrators' mechanisms to produce more commercial research including research with emphasis on individual characteristics.

Other themes for future research build on the limitations of this study itself. For example, this study was based on document analysis of the policies while leaving policy implementations and enforcements aside. Another limitation of this study is the qualitative nature of the comparative analysis and the ranking of the universities at each variable, which implied a series of subjective assumptions and decisions. Finally, the limited sample used constitutes another limitation of this study.

Significant changes are taking place in higher education as academic capitalism grows in American colleges and universities. These changes can be categorized in three main areas, which are epistemological shifts, changes in the academic profession and in graduate education.

Epistemological shifts refer to the increase of managerial and entrepreneurship values in higher education in opposition to the traditional academic norms of knowledge creation and dissemination as well as social service (Gumport, 2002). Some of the most significant changes in the academic profession documented include: overemphasis in applied research (Campbell & Slaughter, 1999; Gladioux & King, 1999; Slaughter et al., 2002); less time spent by faculty in teaching and advising and more time spent in writing grants, reports, patent applications, and other entrepreneurial activities (Gumport, 2002; Kerr, 2002; Milem, Berger & Day, 2000; Slaughter & Leslie, 1997); secrecy of knowledge; and the fostering of a hierarchy based on prestige and salary differences between entrepreneurial faculty and faculty who are not engaged in for-profit ventures (Becher, 1989). Finally, graduate students, who possess research skills, have become valuable labor for industry representatives and tokens of exchange for faculty members in order to consolidate partnerships with private sponsors (Slaughter et al., 2002). As a result, the implications to graduate education and graduate students are significant, especially from an organizational culture and socialization perspective.

By looking at factors that might affect patenting levels at Research I universities, this study offers a perspective to understand faculty behavior in light of academic capitalism. Given the significant impact of academic capitalism on higher education according to previous studies, more studies such as this one would allow us to better understand this new trend in order to discover ways to intentionally guide the fate of higher education in light of external economical and political forces such as academic capitalism.

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