Inside the Triple Helix: An Integrative Conceptual Framework of the Academic Researcher's Activities, a Systematic Review

Norrin Halilem, PhD candidate, ABD
Laval University
2325 rue de la Terrasse
Québec, Québec, Canada G1V 0A6
Tel: (418) 656-2131 # 4388
Fax: (418) 656-2624
Email: norrin.halilem@fsa.ulaval.ca

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Abstract

In the Triple Helix of University-Industry-Government relations, the academic researcher plays a predominant role as he participates in research, which provides opportunities for innovation; in teaching, which develops highly qualified personnel; and in entrepreneurialism, which represents the transformation of knowledge in a more usable form, and so another opportunity for innovation. The changes in the context of the university and of the researcher lead to a need for a more comprehensive understanding of the complexity of the university's universe. To answer this need, a systematic literature review was conducted. From 5,463 articles, 98 were selected that identified four different roles of the researcher (research, teaching, entrepreneurialism, and services), and four levels of variables that influence them: the researcher's characteristics (gender, ethnicity, network, e.g.), the departmental level, the university's characteristics (type, structure, policies, e.g.), and the university's location (city characteristics, entrepreneurial climate, regional policies, e.g.). A contextually sensitive understanding of these variables could provide a more nuanced and creative approach to manage research and entrepreneurial activities, and would provide opportunities to generate best practices to support the researcher.

Keywords: triple helix, university, researcher's activities, researcher's roles

Introduction

In some Organisation for Economic Co-operation and Development (OECD) countries, the interactions of the economic actors are in transition (Inzelt, 2004). A triple helix model of these interactions is emerging, based on a spiral pattern of relations among three meta-actors in a society: Industry, University and Government (Etzkowitz & Klofsten, 2005; Marques, Caraca, & Diz, 2006). None of these three meta-actors prevails on the others; each influences its

own trajectory of actions while every trajectory is influenced by the others (Leydesdorff & Meyer, 2006). Their roles and interests are "intimately intertwined in a complex combination of financial, intellectual, personal and legal relationships" (Campbell, Koski, & Blumenthal, 2004a, p. 4).

Never has the university had such a place. It has been motivated by external pressures such as the emergence of the knowledge economy within which the university, as a knowledge-producing and disseminating institution, plays a larger role in industrial innovation (Meyer, Sinilainen, & Utecht, 2003; Cooke, 2005; Landry, Amara, & Saïhi, 2005); and the steady decline of public funding of research, which increases the competition for public funds (Etzkowitz & Brisolla, 1999). In this context, the university is experiencing its second academic revolution (Jacob, 2000), which leads to the emergence of a third role, beyond teaching and research: the entrepreneurial role (Etzkowitz et al., 2000). The entrepreneurial university is a "key instrument of technology innovation" (Degroof & Roberts, 2004, p. 327).

Two trends in the scientific literature have focused on this new academic environment (Marques et al., 2006). The first is focused on the study of the university's three roles, particularly the horizontal relations among the three meta-actors (Gunasekara, 2005). The second is focused on the institution's internal environment (Kirkland, 2005). In this trend, two orientations were considered: the first is an institutional perspective focused on structure, as implicit and explicit rules of play that define specific constraints and opportunities for actors (Kleinman, 1998). The new academic environment has increased the need for the institutional management of public higher education organisations (Hemlin, 2006b). The university faces formidable legitimacy challenges (Gumport, 2000). Attaining financial freedom will increasingly depend upon the university's willingness and capacity to collaborate with industries and other organisations (Landry, Traore, & Godin, 1996). Consequently, research and entrepreneurial activities, which were until recently seen as quasi-completely individualistic activities, have been increasingly considered as an organisational objective that should be managed accordingly (Fisher & Atkinson-Grosjean, 2002).

There is a growing interest in the way researchers assume their responsibility in terms of research, entrepreneurial and teaching activities (Kreber, 2000; Porter & Umbach, 2001). Consequently, the second orientation is an agent-centered analysis of faculty members' activities — particularly those of researchers, as operators in a highly manipulable environment and subjected to minimal constraint (Landry, Amara, & Rherrad, 2006). However, this orientation seems to correspond only to ivory tower institutions (Etzkowitz & Klofsten, 2005). In an increasing number of other institutions, this orientation does not take into account the growing pressures to which researchers are increasingly subjected (Meyer, Du Plessis, Tukeva, & Utecht, 2005), and prevents them from self-managing in a "completely free environment" (Laperche, 2002).

Each orientation gives only a partial view of the university's complex mechanisms. A more comprehensive understanding of the internal academic environment reveals the need for integration of the different orientations of the literature in a unique conceptual framework (Audretsch & Lehmannb, 2005) that encompasses all the determinants of the researcher's activities and the relation between them. As the literature is disparate, concentrated on different levels of analysis, a complete development of this framework should allow both the mapping and assessment of the existing intellectual territory. A systematic review appears to be the more useful method to manage the diversity of knowledge on a specific academic inquiry (Tranfield, Denyer, & Smart, 2003). Understanding the determinants of the researcher's role has numerous implications both in identifying gaps that can be filled by future research, and in terms of university management (Hemlin, 2006a).

The article begins with a review of the protocols used and the reasoning behind them. A map is then introduced by considering six trends that characterize the field. Researcher activities and the relations between them follow, and a conceptual framework and synthesis of the evidence on the researcher's activities are then presented. The article concludes with an identification of gaps and implications for future research and policy.

Methodology

A systematic review is a methodological process that identifies, evaluates and analyzes research evidence to synthesize and map it (Kitchenham, 2004; Staples & Niazi, 2007). The systematic review is a defined, methodical way of identifying, assessing, and analyzing published primary studies to investigate a specific research question (Staples & Niazi, 2007). It is based on a rigorous, transparent and reproducible process allowing development of the most complete view of the literature for researchers and policy-makers (Tranfield et al., 2003; Kitchenham, 2004). Undertaking a systematic review is increasingly regarded as a fundamental scientific activity, and its frequency in management is growing (Tranfield et al., 2003).

The basic steps of a systematic review include: 1) identifying the need for a review, 2) developing a research protocol (formulating an explicit research question, fixing inclusion and exclusion criteria), 3) identifying relevant studies, 4) selecting the studies according to the inclusion and exclusion criteria, 5) assessing the quality of retained studies, and 6) summarizing and synthesizing study results (Kitchenham, 2004; Staples & Niazi, 2007; Tranfield et al., 2003).

Inclusion and Exclusion Criteria

This systematic review sets out to answer the following three questions: 1) what are the activities related to the researcher's roles, as well as their conceptual and operational definitions? 2) what are the institutional determinants of these activities? And 3) what are the other determinants of these activities?

Articles were selected if they considered one of the researcher's roles as the primary concept and if they answered one of the three questions. Preliminary research identified other inclusion and exclusion criteria. First, the new environment of universities described seems to specifically characterize the OECD countries (Lach & Schankerman, 2003). In these countries, there is a growing trend of links between science and education policies on the one hand, and economic policies on the other (Laperche, 2002; Pilbeam, 2006). Moreover, according to Teodorescu (2001), a common structure of the determinants of the researcher's role in OECD countries would be applied with difficulty to other countries. This leads to the conclusion that the systematic review should consider only articles based on OECD countries. Furthermore, according to Meyer et al. (2005), Lee and Rhoads (2004), and Baldini (2006), in the mid-1990s and particularly since 1995, there has been a shift toward rapid expansion of university commercialization. This leads to the conclusion that the systematic review should consider only documents studying post-1995 situations. As the systematic review process started in 2007, the review was limited to documents that had been published or available by the end of 2006.

Published, peer-reviewed papers and research reports were considered. Books, dissertations and book reviews were excluded, due to time and resource limitations.

Strategy of Localization

The strategy of paper localization included two subsequent phases. The first phase contained three steps: 1) a systematic computerized search within multidisciplinary (ISI Web of Science) and specialized databases (Academic Search Premier, ERIC, CBCA Complete, Current Contents, Francis, Education abstracts), as advised by an expert librarian; 2) a web electronic search using Google and Google Scholar; and 3) sorting documents extracted from the retrieval system according to explicit inclusion and exclusion criteria.

At the end of this phase, 5,463 documents were identified and reviewed, based on the inclusion and exclusion criteria. After initial sorting based on the documents' titles and abstracts, 5,129 documents that did not meet the inclusion and exclusion criteria were excluded. A thorough reading of the full text of the remaining 334 documents excluded an additional 250. Hence, 84 documents survived the double sorting to be included in the first phase of the systematic review. Eighty-eight percent of these came from three electronic databases: ISI Web of Science, Academic Search Premier, and ERIC.

The second phase also included three steps: 1) the most important journals were selected according to the results of the first phase (*Higher Education, Research in Higher Education, Research Policy, Review of Higher Education, Scientometrics*), and a manual search made within volumes published between January 1995 and December 2006; 2) the most prominent authors of the literature selected in the first phase were contacted by email (of 12 authors selected, four responded); and 3) 14 documents were subsequently added. All the identified documents were run through EndNote software to identify and eliminate duplicates. Ninety-eight articles were ultimately selected.

General Characteristics of the Literature

The trend of the publications included is shown in Figure 1, which indicates that the number of works on researcher's activities had remarkably increased, especially at the end of the 1990s. About 95 percent of the reviewed documents are publications from peer-reviewed journals; 5 percent are from research reports. Most of these studies (63.6 percent) are quantitative; 29.9 percent are qualitative, and 6.5 percent are of mixed methods.

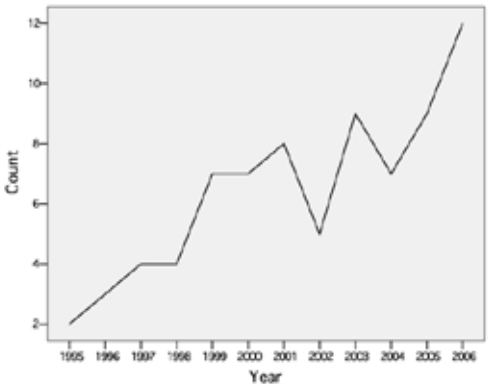

Figure 1: General trend of the literature.

The systematic review process has been developed in more positivist and quantitative disciplines than social sciences and can be followed by a meta-analysis (Tranfield et al., 2003). However, to do so, the literature has to achieve a certain level of maturity, or else different kinds of studies (quantitative, qualitative and mixed method works) must be integrated in the systematic review (Tranfield et al., 2003). This is the case for the literature on researcher's activities. The heterogeneity of the studies prevents the use of a meta-analysis; however, it allows integration of quantitative estimates of effect and a qualitative understanding from researcher's life.

Trends of Analysis Levels

Two levels of analysis were considered in the literature: the institutional (63%) and the individual perspective (37%) (see Figure 2). The two perspectives have grown, but it seems that the individual perspective has grown faster (see Figure 3).

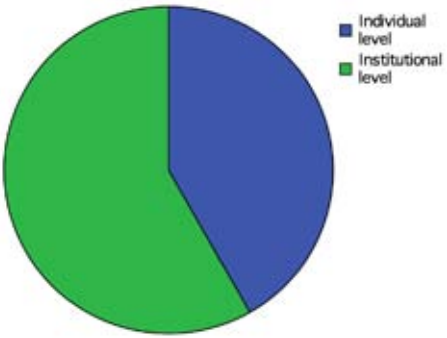

Figure 2: Two levels of analysis.

Figure 3: Level of analysis trends.

The institutional perspective is based on the idea that the university is not simply sustained by a series of individual acts, but also by social and cultural structures and by the institution's practices (Kleinman, 1998). This perspective sheds light on how the university influences the researcher's activities, and particularly the question of policies (Landry et al., 2005). In quantitative studies of this perspective, data were collected at the institutional level (Ramsden, 1999). Unfortunately, the aggregation of individual input and output at the institutional level led to an ecological fallacy in which aggregate-level results may substantially differ or even be the reverse of individual-level results (Porter & Umbach, 2001). This methodological issue would have motivated scholars to concentrate on the individual perspective, although the desegregation of the institutional characteristics to the individual level leads to poor or even misleading policy analysis (Porter & Umbach, 2001).

Proposition 1: Future research should empirically evaluate the membership effect related to the institution affiliation, in other words the assumption that the behaviours of researchers attending the same university are in some respect more alike that of researchers from two different universities. The membership effect is evaluated by considering a multi-level variance analysis, based on hierarchical structures of data (for example, individuals who are affiliated with universities).

Trends of Role Focus

The literature is dominated by a unique research object perspective (see Figure 4); studies are focused on the entrepreneurial role (53%, see for example Atkinson & elGuebaly, 1996; Abbott & Doucouliagos, 2004), on research (39%, see for example Dill, 1995; Azagra Caro et al., 2003), and on teaching (8%, see for example Ediger, 1998; Frost & Teodorescu, 2001). Since 2000, there has been a shift in focus toward entrepreneurialism (see Figure 5). This can be explained by the second academic revolution, which is increasingly felt in the university. Also, there is a decrease in the number of studies focusing on teaching, which are principally considered in the multi-research object perspective. The unique object perspective does not consider the relation between the different roles, particularly when considering the researcher's time budget.

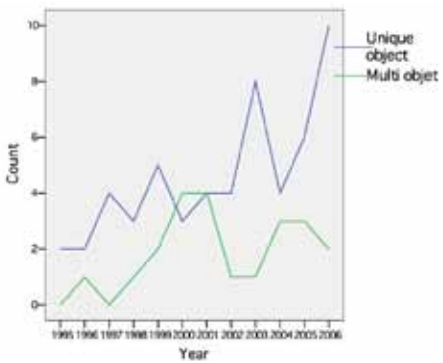

Figure 4: Research object analysis trends.

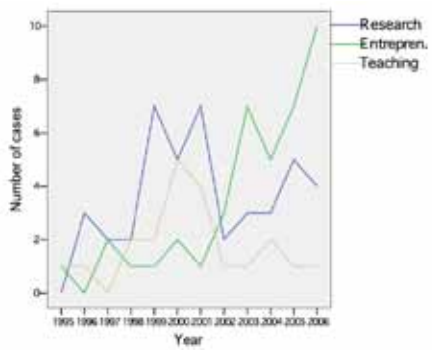

Figure 5: Research object trends.

In the multi-research object perspective, scholars seem more preoccupied by the relationship between research and teaching (44%). This focus reflects a common complaint about higher education —that the emphasis on research detracts from the faculty's involvement in teaching (Serow, Brawner, & Demery; 1999). The relationship between research and entrepreneurialism (24%), and teaching and entrepreneurialism (4%), also seems to be considered, as scholars want to know if the goal of producing commercially valuable knowledge is congruent with the goal of producing research and with teaching activities. Finally, 28% of the multi-research object perspective articles considered all three roles together.

Proposition 2: Future research should consider the multi-research object perspective, and integrate all of the researcher's roles to consider the relationships among them. The use of structural equations or multinomial models can be helpful to consider the relation between researcher's roles.

Trends of Orientation Focus

To study the researcher's roles, different orientations were considered in the literature (see Figure 6): 1) quality (2%, see for example Harley, 2002), 2) performance (12%, see for example Print & Hattie, 1997; Ramsden, 1999), 3) productivity (18%, see for example Rhoades, 2001), 4) commitment (22%, see for example Serow, 2000), and 5) output, which concerns results, patents, and publications (43%, see for example Langford, Hall, Josty, Matos & Jacobson, 2006).

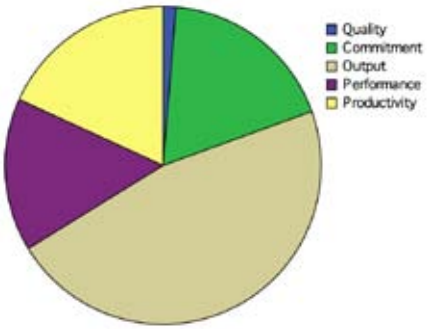

Figure 6: Orientation focus.

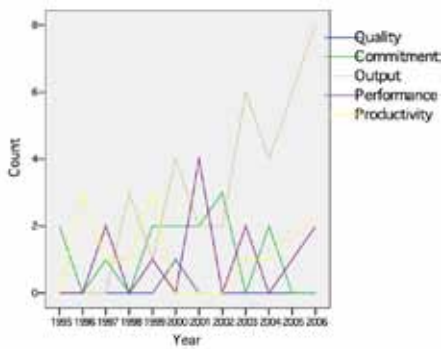

Figure 7: Orientation focus trends.

Since 2002, there has been a shift in focus toward output as the object of research (see Figure 7). There is a parallel between the researcher's context and the literature orientation. According to Langford et al. (2006), there is a risk of isomorphism in the university. The orientation policies on the researcher's activities are focused more on the output than on the activities; scholars spoke about patenting for the sake of patenting (Langford et al., 2006) or publish or perish policies (Ross et al., 1995; Conn, Porter, McDaniel, Rantz, & Maas, 2005). Consequently, outputs such as patenting and publications became measures of success that researchers tended to satisfy. This same phenomenon is found in the literature: scholars are increasingly concerned with output as the object of research, with studies generally focused on one or two outputs, the most common being patents and publication (See for example Azagra Caro et al., 2003; Eugenia Garcia & Sanz-Menendez, 2005).

Proposition 3: Future research should consider the researcher's roles as multi-dimensional concepts to integrate their complexity, instead of working only on a single output such as patent or publication.

Trends of Countries' Orientation

The single nation, non-comparative empirical literature is the most common perspective used by scholars (see figure 8), who studied data collected at the individual or institutional level in only one country. The most studied countries are (see figure 9) the United States (36%, see for example Dai, Popp, & Bretschneider, 2005; Ding, Murray & Stuart, 2006), the United Kingdom (11%, see for example MacBryde, 1997; Calvert & Patel, 2003; Harley, 2003), Canada (10 %, see for example Hum, 2000; Kreber, 2000; Landry et al., 2005), Australia (9%, see for example Print and Hattie, 1997; McInnis, 2000; Abbott and Doucouliagos, 2004), and Finland (6%, see for example Korhonen et al., 2001; Snell, 2001; Meyer et al., 2003). The focus on the United States can be explained by its vanguard policies, such as the Bayh-Dole Act of 1980, which has accelerated the patenting and licensing of university-developed technologies (Campbell, Powers, Blumenthal, & Biles, 2004b), and initiated a University commercialization trend in developed countries (Baldini, Grimaldi, & Sobrero, 2006).

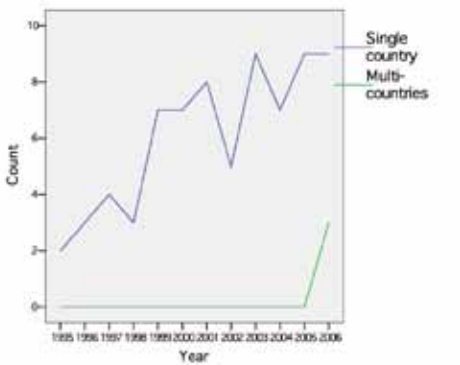

Figure 8: Research object analysis trends.

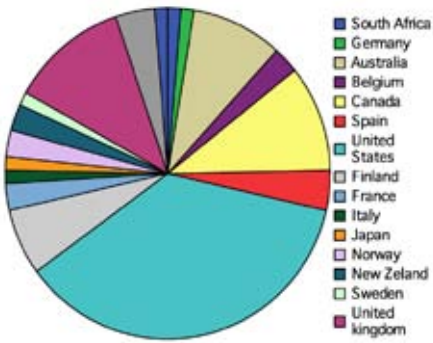

Figure 9: Research object trends.

Cross-national studies are recent in the literature, and based on national comparisons. Geuna & Martin (2003), for example, conducted a comparison of European countries, and Meyer (2006) studied the differences among Belgium, Germany, and the United Kingdom. Cross-national studies typically compare aggregate data at the national level, so scholars experienced the same problem of "ecological fallacy" seen in the institutional model. Moreover, the diversity of the internal environment of a country's universities is lost in the international comparison.

Proposition 4: The single nation, non-comparative perspective seems to be a more congruent way to study a researcher's activities. Even if multi-level modelling treats a hierarchical structure of data at the national level, it requires a high number of countries — and a highly complex data structure— to obtain significant results.

Trends of Discipline Studied

The disciplinary norms view posits that there are large differences in publication productivity and commercialization opportunities across disciplines. These are determined primarily by the traditions, methodologies, and reward structures of each discipline (Teodorescu, 2000). A typology was used to differentiate disciplines: Physical sciences and Engineering (Chemical Engineering, Chemistry, Computer Science, Earth and Planetary Sciences, Energy, Engineering, Materials Science, Mathematics, Physics, and Astronomy); Life sciences (Agricultural and Biological Sciences; Biochemistry, Genetics, and Molecular Biology; Environmental Science; Immunology and Microbiology; Neuroscience); Health sciences (Medicine and Dentistry, Nursing and Health Professions, Pharmacology, Toxicology and Pharmaceutical Science, Veterinary Science, and Veterinary Medicine); and Social Sciences and Humanities (Arts and Humanities, Business, Management and Accounting, Decision Sciences, Economics, Econometrics and Finance, Psychology, and Social Sciences). These four sets of disciplines were equally studied in the literature (see Figure 10). However, when considering the differences between the focus, Social Sciences and Humanities were studied more in the case of Research (35%), but less in the case of Entrepreneurialism (13%). Physical Sciences and Engineering were studied more in the case of Entrepreneurialism (35%). One explanation is that researchers in Physical Sciences and Engineering are significantly more involved in knowledge transfer than their colleagues in other research fields (Landry et al., 2006); they obtain substantially more industry funding and thus commercialize more than the other disciplines (Harman, 2001).

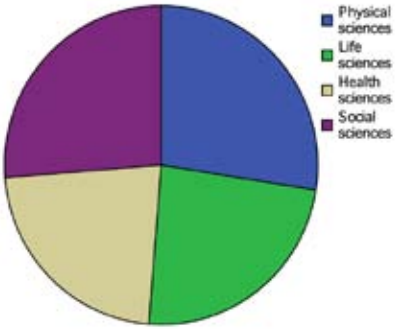

Figure 10: Disciplinary distribution.

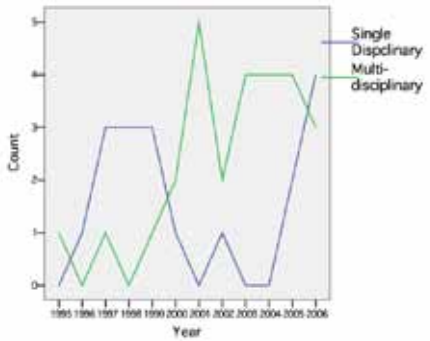

Figure 11: Disciplinary trends.

Two perspectives were considered in the literature: a single and a multi-disciplinary focus (see Figure 11). In the single disciplinary focus, scholars use more case studies, such as MacBryde (1997), who studied a university's commercialization in robotics. In the multi-disciplinary focus, there are more quantitative orientations. In quantitative models, the affiliation to the disciplines is treated as an individual variable instead of as a group affiliation, and so the models presented the same problem of ecological fallacy seen in the institutional model. Only one article considered affiliation in a multi-level model (Porter & Umbach, 2001), but it was not selected for the review because it was based on data collected in 1993.

Proposition 5: Future research should empirically evaluate the membership effect related to the discipline affiliation, in other words the assumption that researchers' behaviours related to the same discipline are in some respect more alike than researchers' behaviours from two different disciplines. The membership effect is evaluated by considering a multi-level variance analysis. One way to do so is through the use of a hierarchical structure of data (for example, individuals affiliated with universities).

Trends of Methods

The methodological trends of the literature on the researcher's role revealed that studies used more quantitative options (see Figure 12). Since the beginning of the 2000s the literature on the researcher's role is dominated by quantitative methodologies.

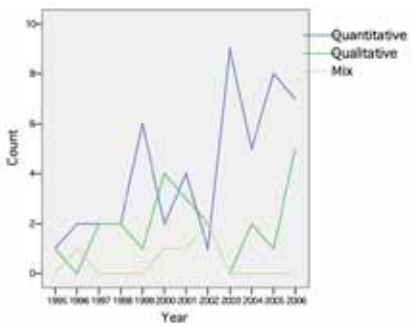

Figure 12: Disciplinary distribution.

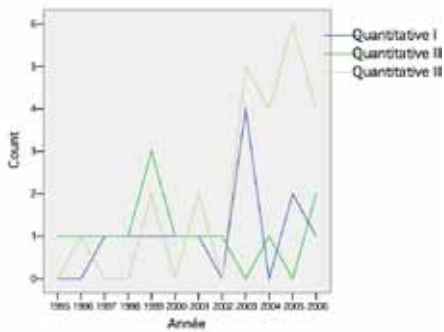

Figure 13: Disciplinary trends.

Three kinds of quantitative methods can be considered: quantitative I (descriptive statistics), quantitative II (correlation, ANOVA, and khi2), and quantitative III (OLS regression, structural equation models, and logistic regression). Figures 12 and 13 show that the increase in 1999 corresponds to an increase of quantitative II; the increase in quantitative I and II is seen between 2003 and 2006. These shifts in the literature are the signs of maturity in theory construction that has allowed scholars to use more complex statistical tests.

Proposition 6: The literature on the researcher's roles seems mature enough to follow the quantitative III methods, even on the question of entrepreneurialism, which is the most recent role.

The Researcher's Activities

A Typology of the Researcher's Activities

Different typologies of the researcher's activities were identified (Presley & Engelbride, 1998; Kumar, Mwamwenda & Dye, 1999; Harley, 2002, etc.). For Vidal and Quintanilla (2000), the researcher is involved in four kinds of activities: teaching, research, services, and management. A study by Kreber (2000) revealed 17 activities aggregated into five groups: 1) interaction/scholarship; 2) teaching, with some aspects of citizenship; 3) extramural activities; 4) academic work routines; and 5) product research. Hemlin (2006) identified six groups: 1) research activities; 2) research funding activities; 3) management of human resources; 4) teaching activities; 5) participation in the management of research departments; and 6) quality control. None of these studies considered the entrepreneurial activities as a group, in contrast to a growing literature (Etzkowitz, 2003; Lee & Rhoads, 2004; de Zilwa, 2005).

Integration revealed the following seven activities: teaching, research, funding research, administration, internal and external services, scientific interaction, and academic routine (Presley & Engelbride, 1998; Kumar et al., 1999; Kreber, 2000; Vidal & Quintanilla, 2000; Harley, 2002; Hemlin, 2006b). These seven activities can be aggregated into four researcher's roles: research, teaching, entrepreneurialism, and services (internal and external).

Research Activities

Research activities may be defined according to four questions: 1) Who is performing them? 2) How? 3) What product? 4) To whom?

In response:

1) Research was defined as a "closed intellectual endeavour confined to the self-referential world" of the researcher (Smith, 2001, p. 137). Consequently, research activities are related to the researcher's characteristics, notably his or her competencies. Research is increasingly conducted by teams instead of individuals (Hemlin, 2006b).

2) Research is a systematic investigation performed with the objective of developing generalizable knowledge (Atkinson & elGuebaly, 1996; Hemlin, 2006b).

3) Research involves the development of tacit knowledge (for example, incorporated in the experience of the researcher), and of explicit knowledge codified in different

supports for the purpose of its dissemination (manuscript, conference presentation, or book, e.g.), and for the purpose of creating commercial value (patent or product, e.g.) (Atkinson & elGuebaly, 1996; Kreber, 2000; Menzies, 2000).

4) Research is increasingly related to the users' context (patricians and clients, e.g.); consequently, it is increasingly oriented on problem resolution (Smith, 2001). Users can thus be involved in the research process, for example, by maintaining communication with the researcher.

In the literature, two kinds of proxies were used: inputs and outputs. In the first category, scholars used the expected workload, the time implications of research activities (Lester, Carter, Dassu & Hobbs, 1998), and funds (the researcher's total funds and the externally funded projects where he or she serves as principal investigator) (Lee & Rhoads, 2004). In the second category, scholars used different publication supports (Ramsden, 1999; Korhonen, Tainio & Wallenius, 2001; Geuna & Martin, 2003; Carayol & Matt, 2004), and citation impact (Korhonen et al., 2001; Itagaki & Pile-Spellman, 2006). More than 20 different supports were considered in the literature, including: 1) articles in scientific journals; 2) scientific books; 3) presentations in conferences; 4) conference proceedings; 5) articles in other journals; 6) book chapters; 7) research funds; and 8) supervision of doctoral or master's students. The first four indicators are the most commonly used (Lester et al., 1998; Kumar et al., 1999; Ramsden, 1999; Abbott & Doucouliagos, 2004; Carayol & Matt, 2004; Itagaki & Pile-Spellman, 2006; Landry et al., 2006).

Proposition 7: Publications are acknowledged to be the most valid, fair and direct measure of research among academics (Print & Hattie, 1997). However, scholars must adapt the outputs of research in accordance with the disciplines; for example, Itagaki and Pile-Spellman (2006), studying radiology research, considered different disciplinary specific types of research production: case reports, review articles, and reports of clinical trials.

Teaching Activities

Teaching is a set of activities that characterise university researchers, in contrast to researchers in industry or in research institutes (Hemlin, 2006b). In addition to classroom hours, lecture preparation, paper-grading, office hours, and selecting graduate students for admission, teaching might include leading an international field trip (McInnis, 2000). Teaching therefore means long days working closely with groups of students developing clinical skills (McInnis, 2000). Teaching is sometimes divided into formal and informal activities (McInnis, 2000), also called instructing and advising (Kreber, 2000; Rhoades, 2001). Instructing is related only to the courses, while advising can be related to extra-course subjects (Rhoades, 2001; Print & Hattie, 1997).

One common finding in the literature is that teaching is hard to measure (Serow, 2000); the number of proxies for teaching is smaller than those for research. Of the former, three kinds of proxies were used: inputs and outputs of activities, and an implication proxy. In the first category, scholars used time spent by the researcher on teaching activities (Fox & Milbourne, 1999; Landry et al., 2005; Landry et al., 2006). Some scholars considered only one part of the time, such as the amount of time spent in class (Ross et al., 1995). In the second category, scholars considered the number of students taught (Ross et al., 1995), and self-evaluation and perception of teaching quality (Lester et al., 1998; Ramsden, 1999). Finally, in the last category, scholars used a composite measure that included, for example, the importance of "Being a Good

Teacher" and the importance of "Opportunity for Teaching" in the choice of career (Lee & Rhoads, 2004). However, Frost & Teodorescu noted that (2001: 402): "faculty generally seemed to view the evaluation of teaching as either a mission impossible". The most commonly used proxy for teaching is thus an input-based consideration of time spent by the researcher on the teaching activity (Rhoades, 2001; Landry et al., 2005): number of hours (Fox & Milbourne, 1999) or fraction of time for a period (Landry et al., 2006).

Proposition 8: When studying input-based measures of teaching, scholars must consider all the time dedicated to teaching activities: the part spent in a classroom, the part of preparation and also the part spent consulting with students.

Entrepreneurial Activities

Entrepreneurialism is defined as a formal effort of faculty members to generate revenue for themselves or for their institution (Lee & Rhoads, 2004). It concerns the economic mission of the researcher (Fisher & Atkinson-Grosjean, 2002), and particularly the commercialisation of knowledge under different mechanisms (Landry et al., 2006). Entrepreneurialism is thus seen as a capitalisation of knowledge to translate research outputs into revenues of research (Dill, 1995). In the literature, three kinds of entrepreneurial orientations of the researcher were considered: 1) commercialisation by direct mode of knowledge and technology transfer, i.e., a direct relation between the researcher and a research user (research contract with industrial actor, consultation activities, e.g.); 2) commercialisation by indirect and intermediate mode of knowledge and technology transfer, where the knowledge and technology transfer office is involved as the owner (indirect) or as a facilitator (owner) (patent development, license, e.g.); and 3) commercialisation by structure creation (e.g., spin-off creation).

In the literature, two kinds of proxies were used: inputs and outputs. In the first category, scholars used industrial funding (Gulbrandsen & Smeby, 2005) and the time dedicated to entrepreneurial activities, for example, outside consulting or freelance work (Lee & Rhoads, 2004). In the second category, scholars used commercial outputs like patents (Azagra Caro et al., 2003; Meyer et al., 2003; Powers, 2003; Carayol and Matt, 2004; Dai et al., 2005; Meyer et al., 2005; Baldini et al., 2006), the establishment of firms (Pirnay et al., 2003; Degroof & Roberts, 2004; Vanaelst et al., 2006), and license income and outcomes (Lach & Schankerman, 2003; Sine et al., 2003; Siegel, Waldman, Atwater & Link, 2004). Other commercial outputs are products or services that are currently marketed, consulting contracts, software with commercial applications and trade secrets (Harman, 2001; Gulbrandsen & Smeby, 2005). The patent is the most commonly used output by scholars.

Proposition 9: As entrepreneurial activities observed in the universities are multi-fold (Yokoyama, 2006), future research should consider the researcher's different commercial outputs from the three entrepreneurial orientations considered in the literature (direct mode, indirect and intermediate mode, and by structure creation) to have a complete view of the entrepreneurial researcher.

Internal and External Service Activities

Internal service activities concern the researcher's participation in the management of research departments, and even in the management of universities (Bernardin, 1996; Hemlin, 2006b). Researchers are implicated in discussions concerning the department's and the university's general scientific objectives, economy, and the wider frames of staff and resource

management (Hemlin, 2006b). External service activities concern notably the implication in quality control and discipline development with examination tasks, by participating in large-scale research evaluations for journals or funding agencies (Bernardin, 1996; Hemlin, 2006b). These activities can be informal or formal (Kreber, 2000).

One input proxy of internal and external services, the number of hours of administrative work per week, was used in the literature (Fox & Milbourne, 1999).

Proposition 10: The time devoted to internal services appears underestimated. Future research should integrate this researcher's role. More qualitative research is needed to develop input and output proxies to consider the complexity of this role.

The Relation between the Different Activities

Three kinds of relations were considered in the literature among the researcher's four roles: complementarities or transferences, the substitution or interference, and the null relation. As the meta-analysis method is not permitted due to the heterogeneity of the studies, an alternative method was used to draw conclusions. Dominant effects were generated by using a vote-counting method (Littell, Corcoran, & Pillai, 2008), which consists of the count of the significant effect directions by considering the same operational definition of the dependent variable, when the number of counted effects was superior to three. So, some dominant effects were considered in the quantitative literature, and particularly within research and teaching (-) and research and entrepreneurialism (+) (See Table 1). There is no evidence on the relation between services and teaching or entrepreneurialism. Furthermore, there is no dominant effect on the other relation.

In a more qualitative view (see Figure 14), it appears that the relations are also multi-fold, so scholars have explored the relation between the different roles to understand when there is transference and interference. For example, there is transference between research and teaching in accordance with the transfer of concept from the first to the second, but there is interference in accordance with the time dedicated to these activities, particularly considering the time devoted to consulting with students. Between research and entrepreneurialism, there is transference when considering the transfer of concepts from the first to the second, and the influence of industrial funding on research productivity. However, there is interference when considering the time dedicated to these activities and the influence of industrial funding on research, particularly publication delay. More research is needed to understand the transference and interference relations between the services and the other activities.

Proposition 11: future research should consider the relations between the different roles as multifaceted. As scholars use different role proxies in terms of inputs and outputs, they can understand this complexity. For example, one common proxy is the time dedicated to the four sets of activities considered in the literature. Studying the relation between the times dedicated can illustrate transference and interference, but it is only one aspect of the relation.

Table 1. Researcher Role Relations

Roles/Roles	Research	Teaching	Entrepreneurialism	Services
Research		-	+	No dom. effect
Teaching	-		No dom. effect	No evid.
Entrepreneurialism	+	No dom. effect		No evid.
Internal services	No dom. effect	No evid.	No evid.	

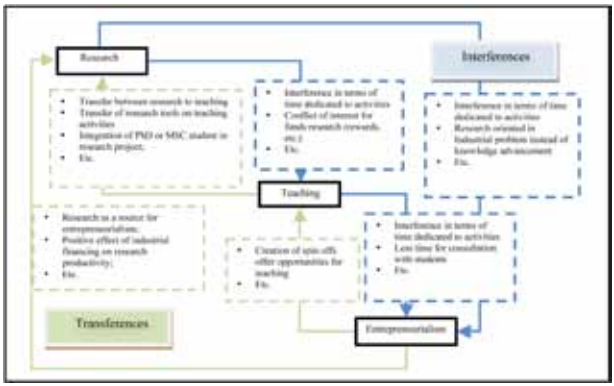

Figure 14: Disciplinary distribution.

Towards a Conceptual Framework

In the literature, different typologies of the variables that influence the researcher's activities were counted. For example, according to Seglen & Aksens (2000), and Johnsrud (2002), there are two groups of determinants —those related to individual variables (such as age, gender, academic background) and those related to structural variables such as the finance structure and the institutional context. Fox (1985, cited by Frost & Teodorescu, 2001) added specificity at the individual level by differentiating variables that belong to the individual background (age, gender, e.g.) and those that belong to individual accomplishment (experience, commitment to certain activities, e.g.). This systematic review revealed that the variables must be considered at a minimum of four levels: the individual, departmental/disciplinary, institutional, and regional (see Figure 15).

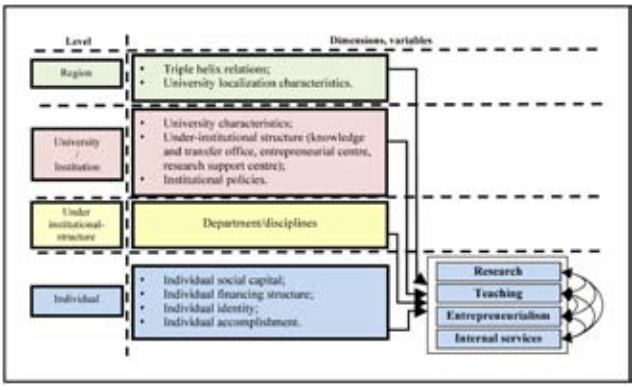

Figure 15: Conceptual framework of researcher's roles.

The first, or individual level, concerns: 1) the individual social capital (alone or part of a group, e.g., or the networks); 2) the researcher's financing structure (public/private, for basic research or oriented on an industry problem, e.g.) ; 3) individual identity (gender, ethnicity, age); and 4) individual accomplishment (the background, the mainstream, non-mainstream

orientation, past performance). The second, or departmental/disciplinary level, concerns the characteristics of the disciplines in accordance with the research productivity or entrepreneurial opportunities, and the different aspects of the department, which is the level where institutional policies are administered. The third level is the university; it concerns 1) the institutional characteristics (the size, the number of campuses, the culture); 2) the presence of different institutional structures and their characteristics (the knowledge and technology transfer office, entrepreneurial and research support centre); and 3) the different institutional policies according to the researcher's roles. Finally, the fourth level is the regional level; it concerns 1) the relation between the university and other actors such as local or federal government and firms, and 2) the characteristics of the university localization (e.g., the regional entrepreneurial climate).

Proposition 12: As some authors have pointed out, individual characteristics tend to weigh more in predicting activity proxies than do institutional influences (Serow et al., 1999; 2000; Link & Scott, 2005); however, as no selected article used a multi-level model, this conclusion must be confirmed. Future research should consider determinants at these four different levels, and particularly the researcher's affiliation to them; however, the proxies of the researcher's activities should be considered at the individual level.

Evidence on the Researcher's Activities

In the quantitative literature, the study of the determinants of the researcher's activities identified a dominant effect in the four levels of the conceptual framework (see Table 2). Dominant effects were generated by using a vote-counting method (Littell et al., 2008), by considering the same operational definition of the dependent variable. This means, for example, that evidence on entrepreneurial activities was considered differently if it referred to spin-off creation, patents or consultation.

At the Individual Level

Experience.

The more experienced the researcher, the more he or she is likely to produce research and undertake entrepreneurial activities. Experienced researchers may have more to sell, and could be less motivated by traditional academic incentives (tenure, disciplinary awards) than by greater financial incentives expected from the commercialization of their results (Landry et al., 2006).

Status.

Evidence suggests that full professors are more likely than assistant and associate professors to disclose inventions and patents. As full professors have generally fewer institutional constraints and more freedom than their counterparts, they could be more motivated to consider entrepreneurial activities (Siegel et al., 2004).

Star scientist.

Entrepreneurial activities appear concentrated within a minority of researchers who are also more productive in research, and whose research represents an intellectual capital base of extraordinary value and entrepreneurial opportunities (Meyer, 2006).

Career path.

Evidence suggests that senior academics are more likely to consider entrepreneurial activities and to attract industrial funds than junior academics, who often seem confused and ambivalent about how attracting industrial funds might influence their research orientation (Harman, 2001). Moreover, research, and particularly publication performance, is also strongly negatively correlated with junior positions (Carayol & Matt, 2004).

Gender.

Usually used as a control variable; evidence suggests that Male academics appear more likely to consider entrepreneurial activities. For example, Ding (2006) found that female academics in life sciences patent at 0.40 times the rate of equivalent male academics. One explanation for this difference is that female academics are more committed to teaching than their male counterparts (Lee & Rhoads, 2004).

Social capital.

Evidence suggests that a researcher's networks influence his or her patenting behavior. Collaboration by researchers is conducive to higher productivity, whether it is with universities, industries or institutions. Also, relations with coauthors, colleagues, and industry actors give the researcher opportunities and support for the patent process (Ding et al., 2006).

Financing structure.

Researchers financed by basic research funds appear more likely to patent their findings. According to Dai et al. (2005), basic research can serve as a knowledge base for future applied research and for patents. As federal-applied research funds are intended to produce research oriented on certain technological needs, they lead to commercialization (Dai et al., 2005), but they have a negative impact on the creation of university spin-offs (Landry et al., 2006). Moreover, the financing structure also has an influence on the commitment to teaching; researchers who use funding toward their research are somewhat less committed than faculty who do not (Lee & Rhoads, 2004).

At the Departmental/Disciplinary Level

At the Institutional Level

Researchers appear more likely to consider entrepreneurial activities when their university has adopted IPP. Universities with IPP typically provide two kinds of remuneration to motivate the researcher in the commercialization process: 1) a performance-based payment structure, such as licensing royalties; or 2) an equity compensation (Goldfarb & Henrekson, 2003).

Knowledge and technology transfer office (KTTO).

Evidence suggests that the presence of a KTTO, and some of its characteristics, has a positive effect on a researcher's commercialization process. The role of the KTTOs is to manage intellectual property and commercialization. For example, KTTOs encourage and solicit research grants from government and industry, identify and protect discoveries (patenting and registering, e.g.), and promote university intellectual property (Hum, 2000). The KTTO's size and age (number of years since its creation), and the technical orientation of its managers make

a KTTO more effective in realizing the full potential value of inventions (Lach & Schankerman, 2003; Siegel et al., 2004).

Former university creations and commercialization.

Evidence suggests that former university activities have an influence on a researcher's entrepreneurial activities. For example, former start-up creations lead new researchers to believe that firm formation is acceptable and desirable (O'Shea, Allen, Chevalier & Roche, 2005).

Prestige.

A university's prestige appears to have a positive effect on a researcher's entrepreneurial activities, particularly on licensing. A university's prestige seems to produce a halo effect on researcher's creations, thus increasing his or her rate of licensing (Pilbeam, 2006).

University size.

Evidence suggests that the larger the size of the university, the more researchers engage in entrepreneurial activities. One explanation is that larger sized universities have a greater reservoir of resources and expertise linked to financial resources, laboratories, and technology transfer offices (Landry et al., 2005).

At the Regional Level

University-industry relation.

Evidence suggests that university–industry ties and closer partnerships with industry result in greater levels of commercialization. For example, the greater the proportion of industry-funded research received by the university as a proportion of total research and development funding, the greater the propensity to create spin-off firms (O'Shea et al., 2005). It is interesting to note that, at the individual level, industrial funding has an opposite effect on the creation of spin-off firms.

Entrepreneurial climate.

The entrepreneurial climate appears to have a positive effect on a researcher's commercialization. Universities and researchers are more likely to interact with firms located geographically close to each other, and the density of firms in a high-technology sector has a positive influence on the licensing of universities' and researchers' patents (Sine, Scott & Di Gregorio, 2003; Baldini et al., 2006).

Gaps in the Literature

Finally, in the quantitative literature, the study of the determinants of the researcher's activities identified some gaps in the four levels of the conceptual framework (see Table 2). The gaps mean the absence of quantitative evidence or dominant effects about the influence of a determinant on the researcher's entrepreneurial activities. For example, more research is needed on the influence of the intrinsic motivations and the personal goal-settings on the researcher's entrepreneurial behaviour. This is also the case for the influence of the institutional policies, and notably the question of incentives and support.

Table 2. Determinants of the Researcher's Entrepreneurial Activities

Level	dimension	Variables	Nb of articles where the determinant is cited	Nb of articles where the determinant effect is tested	Effect on the researcher entrepreneurial activities	Effect on the researcher research activities	Effect on the researcher teaching activities	Selected references
Individual	Accomplish.	Intrinsic motivations and personal goal-setting	5	0	No evidence	No evid	No evid	(Lester et al., 1998; Serow et al., 1999; Johnsrud, 2002, etc.)
		Personal assets: experience	9	3	+	+	No evid	(Itagaki and Pile-Spellman, 2006; Landry et al., 2006; Rosa and Dawson, 2006, etc.)
		The status	12	6	+	(-)(0)(+): No dominant effect	+	(Fox and Milbourne, 1999; Siegel et al., 2004, etc.)
		Type of researcher: mainstream or non mainstream	1	0	No evidence	No evid	No evid	(Harley and Lee, 1997)
		Type of researcher: star scientist	5	2	+	+	No evid	(Meyer et al., 2003; Lowe and Gonzalez-Brambila, 2005, etc.)
		Personal assets: past performance	1	0	No evidence	No evid	No evid	(Keith, 2001)
		Career Path	9	5	+	+	No evid	(Landry et al., 2005; Lowe and Gonzalez-Brambila, 2005, etc.)
	Identity	Etnicity	1	1	+	No evid	No evid	(Lee and Rhoads, 2004)
		Gender	11	8	-	-	+	(Ding et al., 2006; Rosa and Dawson, 2006, etc.)
	Social capital	Social capital	10	6	+	+	No evid	(Gulbrandsen and Smeby, 2005; Hemlin, 2006a, etc.)
		Research group	4	2	No evidence	+	No evid	(Carayol and Matt, 2004; Vanaelst et al., 2006, etc.)
	Financing Structure	Federal basic research support	10	6	+	+	-	(Hornbostel, 2001; Dai et al., 2005, etc.)
		Federal applied research support	5	4	(+)(0)	+	No evid	(Azagra Caro et al., 2003; Gulbrandsen and Smeby, 2005, etc.)
		Industry financial support	9	6	(+/-)	+	No evid	(Geuna and Martin, 2003; Landry et al., 2006, etc.)
Under institutional structure	Dep.		7	0	No evidence	No evid	No evid	(Lee, 1996; Whitman et al., 1999, etc.)
	Disc.		33	15	(+/-)	(+/-)	(+/-)	(O'Shea et al., 2005; Pilbeam, 2006, etc.)
University/ Institution	University policies	Training	4	0	No evidence	No evid	No evid	(Jacobson et al., 2004; Rasmussen et al., 2006, etc.)
		Incentives	27	1	No dominant effect	(+): no dominant effect	No evid	(Rappert and Webster, 1997; Goldfarb and Henrekson, 2003, etc.)
		Intellectual property policies	16	3	+	No evid	No evid	(Hum, 2000; Sine et al., 2003, etc.)
		recruitment emphasis	3	0	No evidence	No evid	No evid	(Pratt and Coy, 1996; Harley and Lee, 1997, etc.)
		Faculty course release policies or teaching requirements	8	3	No dominant effect	No evid	-	(Bernardin, 1996; McInnis, 2000, etc.)
		audit and assessment policies; policy and goals clarity	9	0	No evidence	No evid	No evid	(Korhonen et al., 2001, etc.; Laperche, 2002)
	Institutional Unity	Support Structures for Grant Writing and Research	1	0	No evidence	No evid	No evid	(Conn et al., 2005)
		External Consultation on research productivity	1	0	No evidence	No evid	No evid	(Conn et al., 2005)
		The presence of an entrepreneurial centre	1	0	No evidence	No evid	No evid	(Menzies, 2000)
		The presence of a University-affiliated incubator	5	1	0	No evid	No evid	(Pirnay et al., 2003; Degroof and Roberts, 2004, etc.)
		The presence of a KTTO	15	1	+	No evid	No evid	(Hum, 2000; Goldfarb and Henrekson, 2003, etc.)
		KTTO: staff size	5	4	+	No evid	No evid	(Dill, 1995; Powers, 2003, etc.)
		KTTO: financial resources	5	1	+	No evid	No evid	(Fisher and Atkinson-Grosjean, 2002; Baldini et al., 2006, etc.)
		KTTO: nb of year since creation	5	3	+	No evid	No evid	(Dill, 1995; Lach and Schankerman, 2003, etc.)
		KTTO: manager experiences	2	1	+	No evid	No evid	(Dill, 1995; Fisher and Atkinson-Grosjean, 2002, etc.)
		KTTO: Technical orientation	2	1	+	No evid	No evid	(Dill, 1995; Fisher and Atkinson-Grosjean, 2002, etc.)
		Past entrepreneurial activities of the University	3	2	+	No evid	No evid	(Sine et al., 2003; O'Shea et al., 2005, etc.)

... Table 2 Continued

Level	dimension	Variables	Nb of articles where the determinant is cited	Nb of articles where the determinant effect is tested	Effect on the researcher entrepreneurial activities	Effect on the researcher research activities	Effect on the researcher teaching activities	Selected references
University/ Institution	University characte-ristics	Institutional type	7	3	No dominant effect	No evid	No evid	(Lach and Schankerman, 2003; Pirnay et al., 2003, etc.)
		Institutional size	11	9	+	(+)(0):no dominant effect	No evid	(Azagra Caro et al., 2003; Landry et al., 2006, etc.)
		Institutional resources	10	5	No dominant effect	+	No evid	(Jacobson et al., 2004; Rasmussen et al., 2006, etc.)
		The presence of a medical school	4	4	0 : No effect	(-):no dominant effect	No evid	(Sine et al., 2003; O'Shea et al., 2005, etc.)
		University culture	12	0	No evidence	No evid	No evid	(Schulte, 2004; Dai et al., 2005, etc.)
		Nb of campuses	1	1	No evidence	(+): no dominant effect	No evid	(Abbott and Doucouliagos, 2004)
		University prestige	12	3	+	(+): no dominant effect	No evid	(Meyer et al., 2003; Degroof and Roberts, 2004, etc.)
		Institutional structure	3	0	No evidence	No evid	No evid	(Laperche, 2002; O'Shea et al., 2005, etc.)
		University orientation	22	3	No evidence	(+/-): no dominant effect	(+/-): no dominant effect	(Johnsrud, 2002; Jacobson et al., 2004, etc.)
		Nb of year since University creation	2	0	No evidence	No evid	No evid	(Court, 1999; Harley, 2002, etc.)
		Human capital	4	2	No dominant effect	No evid	No evid	(Pratt et al., 1999; Powers, 2003, etc.)
		Deans characteristics: values, turnover, etc.	6	0	No evidence	No evid	No evid	(Keith, 2001; Rosser et al., 2003, etc.)
		Bulding, classroom, equipment and technology	2	0	No evidence	No evid	No evid	(McInnis, 2000; Frost and Teodorescu, 2001, etc.).
Region	TH Relations	University government relations	3	2	+	No evid	No evid	(Ramsden, 1999; Powers, 2004, etc.)
		University Industry relation	10	6	+	+	No evid	(Gumport, 2000; Calvert and Patel, 2003, etc.)
	University location characte-ristics	Entrepreneurial climate	12	6	+	No evid	No evid	(Laperche, 2002; Degroof and Roberts, 2004, etc.)
		University Geographic location characteristics	6	3	No dominant effect	(0): no dominant effect	No evid	(Meyer et al., 2005; Pilbeam, 2006, etc.)

Conclusions

This systematic review generated 12 propositions dedicated to the development of future research and identified gaps in the way researcher's activities are influenced by some determinants. The systematic review conclusions offer insights into the quantitative research perspective that suggest future research should consider a hierarchical data structure and multi-level models to integrate the influence of determinants related to different levels (individual, departmental and institutional). A more direct and fair method seems to be the study of behaviour in large organizations like universities. At the individual level, structural equation multivariate models can be used to study the relations between entrepreneurial activities and others. It is possible to combine the structural equation or multivariate models with a hierarchical structure of data to do a multivariate multi-level model. In accordance with the proxies of the researcher's activities, future research should adapt research outputs according to disciplines and consider all aspects of teaching activities (time, preparation and consulting). Moreover, future research should consider more than one output of the entrepreneurial activities, such as patents, consultation and spin-offs.

In the qualitative research perspective, more research is needed on the understanding of service activities and on the way they influence the entrepreneurial activities.

This systematic review presents one limitation. Even if vote counting is an alternative method to draw conclusions in a systematic review, it is not as rigorous as the meta-analysis method. For example, the meta-analysis methods take into account the sample size effect, which was not considered in the vote counting method. However, as there is a shift in the literature towards a domination of quantitative III methods (since 2002), the literature is going to achieve a certain level of maturity, allowing the use of meta-analysis methods.

Policy-makers must consider the complexity of the researcher's roles and activities. Incentive policies could change the behaviour of researchers in an unpredictable way. Moreover, these policies are based on weak empirical evidence; more research is needed to assess the efficiency of university policies rather than assume their effects (Geuna & Nesta, 2006). The use of the conceptual framework can be linked to more sophisticated heuristics to target policy initiatives. In this regard, a contextually sensitive understanding of the individual, departmental and institutional determinants that influence researchers' activity outputs may be useful. This could provide policy-makers and practitioners with a more nuanced and creative approach to manage research and entrepreneurial activities, and would provide opportunities to generate best practices to support the researcher.

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