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The Role of Entrepreneurial Universities within Innovation Systems: An Overview and Assessment

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ABSTRACT[2]

Nowadays one observes an increasing interest in the entrepreneurial behaviour of universities. In this contribution the role of entrepreneurial universities within national innovation systems is situated. Specific attention is being paid to the alleged presence of unintended side effects on the level of scientific activities, and the role of legislative framework conditions that might foster a more active role of universities in terms of technology development. After reviewing both issues, combining technological and scientific activity does not only seem feasible, it might even be desirable given the ambitions of Europe within the current, global, knowledge economy.

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I. Introduction: The Phenomenon of Entrepreneurial Universities

Collaboration between science and industry, and the phenomenon of 'enterprising universities', have been studied extensively over the last few decades. This growing interest is connected to the increasing acknowledgement of the fundamental role of knowledge and innovation in stimulating technological performance, international competitiveness and economic growth. Researchers in the domain of innovation (including Freeman, 1987, 1994; Lundvall, 1992; Nelson, 1993; Nelson and Rosenberg, 1993; Mansfield & Lee, 1996; Mansfield, 1995; Mowery and Nelson, 1999; Dosi, 2000) stress the role of science and the importance of interaction between a variety of institutional actors underlying the innovative capacity and consequent economical performance of an economical system. This more encompassing view on innovation dynamics has resulted in a growing popularity of the 'innovation system' concept which gained acceptance by scholars and policy makers alike as a guiding framework to understand innovation dynamics on an aggregated level (OECD, 1999; European Innovation Scoreboard, 2002).

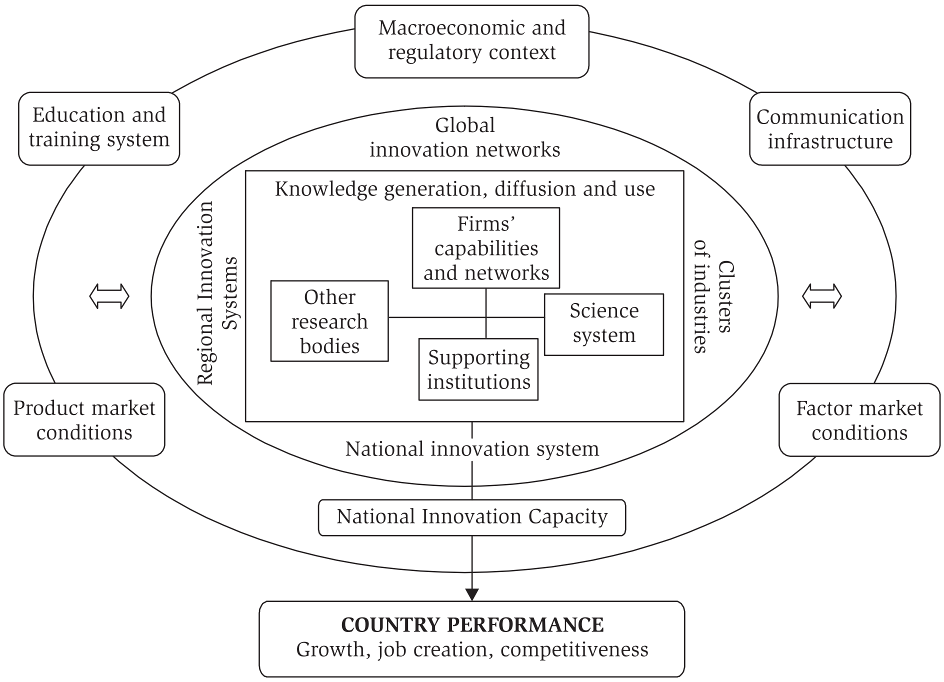

Figure 1. National Innovation Systems: OECD (1997).

In these models, knowledge generating institutions such as universities, research laboratories, industrial research centres and more recently government institutions are acknowledged – besides firms and entrepreneurs – as important players in developing and stimulating the innovative capacity of a particular region or country. Likewise, the Triple Helix model, which emerged in the second half of the 1990s (Leydesdorff and Etzkowitz, 1996, 1998; Etzkowitz and Leydesdorff, 1997; Leydesdorff and Etzkowitz, 1998), emphasizes both the complementary roles of firms, knowledge creation institutes, including universities, and governmental agencies, as well as the importance of constructive interactions among them.

There are multiple reasons why universities are relevant actors within innovation systems and can contribute to the national innovative capacity. First, research institutions produce information and ideas upon which the development of new products, processes and services can build. Secondly, research institutions can work on certain research agendas for a longer period of time, which can lead to the creation of new scientific insights. The latter can over time lead to economic applications. Notice in this respect that universities are well placed to address market failures that occur in the field of innovation (Arrow, 1962; Freeman, 1994; Baumol, 2002). Such market failures arise especially in relation to basic research, characterized not only by high levels of uncertainty both in terms of technical and commercial success, but also spanning long time frames to bear fruit (often decades). In addition, the nature of the outcomes of innovative activity – i.e. knowledge or information – complicates investment decisions even further (Foray, 2004). All these phenomena pose specific challenges for private investors, who tend to refrain from becoming involved in basic research activities. In order to avoid a loss of social welfare – due to non investment behavior of private firms – most national innovation systems nowadays invest considerably in basic research performed at universities and public research institutes.

As such, knowledge institutions like universities can play a specific role related directly to the potential these institutions possess to avoid technological lock-in phenomena. In order to continuously stimulate economic growth within a particular region or nation, based on knowledge intensive entrepreneurship, its technology portfolio should strike a balance between routine technological activities on the one hand (these are focused on process and incremental development in the more mature phases of the technology life cycle) and non-routine technological activities on the other hand (these are more focused on new technology platforms and fundamental developments). Local/regional knowledge centers, especially universities and research centers, can play a significant part in this respect. As they participate in high level scientific research, they contribute to the generation of new knowledge. Such research takes place in international research communities. The exploration of new fields of knowledge[3] – that can often not yet be categorized as routine activities – and the continued diffusion of this knowledge among regional actors can be considered an essential task of knowledge centers and especially universities. This double dynamic allows knowledge centers to play a fundamental role in regional innovation networks. These institutions are best placed to offer support in regard to the dual challenge of local and global knowledge development (Debackere, 2000; Van Looy et al; 2003; Lester, 2004; Debackere & Veugelers, 2005). If a particular region fails to include this dual task as a priority in their regional innovation policy, there is a long term risk of regression and growth stagnation due to the life cycle phenomenon. It is in this context that the significance of knowledge centres should be seen: they develop non-routine activities in research communities which participate in knowledge exchange on an international scale. As such, universities offer regions exploration possibilities that are essential for mid to long term innovation potential. Lester points in this respect to the importance for innovation of 'interpretative', problem defining activities, besides analytical, problem solving ones. When enterprises focus on the latter, it is essential that sufficient attention is paid to creating an environment for exploration. In this sense, universities, as fora where new ideas can be explored and studied, are indispensable.

These reflections also imply that universities are more effective in this respect as they are more active in scientific research. Recent research in the US as well as in Europe confirms this relation: an explicit research focus coincides with a larger number of enterprising activities (patents, spin-offs, contract research) (di Gregorio & Shane (2003); O'Shea, Allen; Van Looy et al, 2005; Sapsalis et al. 2006).

At the same time, contributing effectively to the innovative capacity of an innovation system requires a willingness of universities to become more 'entrepreneurial'. The notion of 'entrepreneurial universities' (Branscomb, Kodama & Florida, 1999; Etzkowitz, Webster & Healy, 1998) refers to the development of the following spectrum of activities: more intense commercialization of research results, patent and license activities, spin-off activities, collaboration projects with the industry, and greater involvement in economic and social development. As such, one observes a 'second academic revolution'[4] whereby education and research become complemented with service and valorization activities aimed at transferring new scientific knowledge to economical activity realms.

Many factors have contributed to the development of the phenomenon of entrepreneurial universities and, at least in the US, this should be considered a logical consequence of the successful involvement of universities in the 1940s, 50s and 60s[5] in domains such as the space industry, defense and energy. Shifts in the federal financing policy and taxation changes for R&D expenses have contributed to more entrepreneurship at US universities. Moreover, in the 1980s policy priorities shifted to R&D activities that contribute to the productivity and worldwide competitiveness of the American industry (Cohen and Noll, 1994).

Likewise, European considerations related to its competitiveness in today's globalized knowledge economy, not only resulted in the well known Lisbon targets; increasingly the role of universities within the European Research Area is being discussed and reflected upon (see for instance, EC Green paper, 2007; Aghion et al., 2007; Dosi et al.; 2007). Recent recommendations published by the EC advance as well a more entrepreneurial orientation of European universities: "Knowledge transfer must improve in order to accelerate the exploitation of research and the development of new products and services. To that end, European universities and other public research institutions should be given incentives to develop skills and resources to collaborate effectively with business and other stakeholders, both within and across borders" (EC Green paper, p. 7).

It is self evident that research centers and universities can only achieve this status if they acknowledge service and entrepreneurship as part of the university's responsibilities and translate this enterprising attitude into a more entrepreneurial university culture, including creating the required adequate supporting transfer mechanisms that facilitate and stimulate these enterprising activities (Bozeman, 2000; Etzkowitz, 1983, 1999; Debackere, 2000; Debackere & Veugelers, 2006).

Several studies have empirically confirmed the role of knowledge centers in regional development (Anselin et al., 1997; Varga, 1998; 2000; Blind & Grupp, 1999; Acs et al., 2002; Fischer & Varga, 2003). Besides direct effects, it has also been shown that the presence of knowledge centres is taken into consideration by companies choosing a location (E.g. Niosi and Bas, 2001). At the same time, the development of such dynamics imply a long term perspective: the slow emergence of high tech regions such as Silicon Valley, Cambridge and Sophia Antipolis show that economic effects are the result of a decades-long development process (Saxenian, 1994: O'Mara, 2005).

II. Entrepreneurial Universities: Concerns

A. Scientific and Entrepreneurial Activities at the Level of Professors: Complementary or Contradictory?

At the same time, the increasing trend of developing entrepreneurial capabilities in academia gave rise to several concerns related to the role of academia within society (Gibbons, 1999; Kelch, 2002; Martin, 2001, 2002). Indeed, an explicit fear is related to the impact of University-Industry cooperation on the research agendas of university researchers (Geuna, 1999; Hane, 1999; Vavakova, 1998) and the conflicts of commitment and interest that occur when faculty members' full-time duties (teaching, research, time with students and service obligations to the university) are affected by activities stemming from involvement in company cooperation such as consulting activities, notwithstanding the observation that most universities have formal policies regarding and regulating this issue. The major concerns derive from the fundamentally different reward and incentive systems of academic and private sector research, in terms of (1) the relationship between disclosure versus secrecy and (2) the complementarities and substitution effects between public and private R&D expenditures (Dasgupta and David, 1987, 1994).

In terms of incentive systems, one of the cornerstones of the academic enterprise consists of the publication of research results and the opportunity for open discussions among colleagues. Companies, on the other hand, have a responsibility for and a need to protect the value of their investments. These differences in the incentive systems of public and private research create challenges with regard to the dissemination of information, the nature of the research conducted and the access to research results (Hane, 1999) and are, therefore, re-opening debates on the norms and values that guide academic science (see, for instance, Merton, 1968 a,b; Mitroff, 1974; Mulkay, 1976). For example, some forms of publication might be delayed or suppressed because firms may ask universities to keep information (temporarily) confidential. This might reduce the incentive to publish and run counter to the academic norm of open dissemination of scientific knowledge (Blumenthal et al., 1996). Florida and Cohen (1999) referred to this as the 'secrecy problem' in research universities. Empirical evidence has, indeed, shown an association between industry support for research and restrictions regarding the disclosure of the research performed. Blumenthal et al. (1996) surveyed life science faculties and companies supporting these faculties. They found evidence for the fact that delaying publications and restricting information sharing are quite common, for instance, to allow sufficient time for the sponsoring company to file a patent application, to protect the financial value of certain research results, or to avoid undermining the competitive status of the sponsoring company. Brooks and Randazzese (1999) cite other empirical evidence of the 'secrecy problem' but also point to a possible effect of the research institute characteristics in the sense that the best research universities seem quite capable of protecting their traditional values of openness and seem to make only modest concessions to the practical needs of industry.

Besides the 'secrecy problem', it can be noted that both individual researchers and research institutions can develop financial interests in the specific research outcomes, leading to a possible bias towards certain fields and activities (ACE, 2001). This phenomenon brings us to one of the main concerns of the opponents of intensifying collaborations between universities and industries, namely that the academic research agenda will be 'contaminated' by the application-oriented needs of industrial corporations – the 'corporate manipulation thesis' (Noble, 1977). From this perspective, university research is seen as characterized by an independence that should allow academics to freely contribute to theories and models at the endless frontier of science, in a (purely) curiosity-driven approach. The corporate manipulation thesis argues that corporations interfere with the normal pursuit of science and that they seek to control relevant university research for their own ends, rather than allowing faculty members to advance their research agenda through the pursuit of opportunities for federal and industrial funding.[6] The changes in the university research agenda are most often related to an alleged shift towards the more applied research end, referred to as the 'skewing problem' (Florida and Cohen, 1999).

Earlier empirical evidence on both problems appears to be rather scarce and of a mixed nature. Surveys by Rahm (in Florida & Cohen, 1999) and Morgan (in Florida & Cohen, 1999) found some empirical association between greater faculty involvement in industry and increased levels of applied research. Research centers that value the mission of improving industrial products and processes devote less of their R&D activities to basic research than centers that do not value this industry-oriented mission.[7] Additional evidence in this respect has been reported for Norwegian university faculties (Gulbrandsen and Smeby, in Geuna and Nesta, 2003). Here, it was found that faculties with industry funding undertook significantly less basic research than researchers with no such external funds. In the same research setting, approximately 20% of the researchers reported contract research to be problematic for the autonomy and independence of their research. In this respect, it can be noted that certain research centers have made collaboration with industry – or involvement in business networks – an explicit part of their mission. Likewise, certain funding mechanisms also favor cooperation between Industry and University, in the US, Japan and Europe (Florida & Cohen, 1999). Hence, the direction of this relationship remains to be resolved. On the one hand, it may be that researchers adjust their agendas in response to an increased cooperation with industry. On the other hand, industrial partners might, nonetheless, turn to research centers with an application-oriented agenda rather than to centers known for performing basic research. In the latter case, the observed effect is only a selection effect.

At the same time, several studies react to the opponents of industry involvement on the grounds of an alleged skewing of the research agenda. Those studies show that performing more applied research does not necessarily imply a trade-off with basic research. For instance, data from the US National Science Board have shown that in the 1980s, although the number of university-industry research centers almost doubled, the overall share of university research, classified as basic research, remained quite stable. Hicks and Hamilton (1999) found that the percentage of basic research that was performed at universities remained unchanged between 1981 and 1995, a period during which, at the same time, a sharp increase in university patenting could be observed. They also reported that the number of citations for university-industry papers was higher than for single university papers, which suggests that university researchers may be able to enhance their scientific impact by collaborating with industry partners. Godin and Gingras (1999), when analyzing publication data from Canadian researchers over a 15-year period (1980-1995), conclude that: "beliefs that collaborative research (with industry) is detrimental to academic research do not seem to be empirically grounded". Similar observations are advanced by Brooks and Randazzese (1999) within the US semiconductor industry, where a consortium of semiconductor producers (SRC) funded university semiconductor research. No indication was found that the SRC support led academics to conduct less 'foundational' research (Brooks and Randazzese, 1999). Recently, Owen-Smith (2003) highlighted the changed relationships between commercial and academic systems. Whereas these used to be separate systems, Owen-Smith's findings suggest that commercial and academic standards for success have now become integrated into what is called a hybrid regime, where achievement in one realm is dependent upon success in the other. This observation has been confirmed by previous research in which the relationship between scientific performance and engagement in contract research with industry was examined more systematically (Ranga et al, 2003; Van Looy et al. 2004). The findings revealed that contract research and scientific activities do not hamper each other: systematic engagement in contract research coincided with increased publication outputs, without affecting the nature of the publications involved. As resources increased, the positive relation between both types of activities became more pronounced, pointing to a Matthew effect.

Contract research, however, represents only one type of entrepreneurial activity occurring at universities. In the case of inventions, the potential conflict between public- and private-oriented considerations in terms of diffusion of knowledge (secrecy versus free dissemination) seems most salient. In that respect, analyzing publication outputs of academic inventors – and comparing them to those of non-inventors – provides additional insights into whether an academic's entrepreneurial and scientific activities can be reconciled or whether they are of a more conflicting nature.

Our own research, involving academic staff at the K.U.Leuven, confirms the findings with respect to contract research: academic inventors systematically publish more than their colleagues who are not engaged in patenting activities but who are working in similar fields and who have comparable age and career profiles (Van Looy et al., 2006, for further refinements and extensions, see also Callaert (forthcoming)). These observations are in line with recently published empirical studies which look in detail at the relationship between (scientific) publication behavior and entrepreneurial activities, including patenting. An inspection of table 1 reveals that no single study reports on trade-offs between both activities; on the contrary the majority of studies clearly signals a positive relationship between inventive activity (measured by involvement in patent activity) on the one hand and scientific activity (measured by publication based indicators) on the other hand.

So while the aforementioned concerns (secrecy, skewing, …) deserve our ongoing attention, recent empirical assessments confirm that universities have found ways to reconcile both activities.

B. **On the Role of Legislative Framework Conditions**

In terms of policy measures, the rise of the entrepreneurial university phenomenon is often associated with the Bayh-Dole Act (1980) and the Stevenson-Wydler Act (1980). These American legislative initiatives created transparency with respect to the ownership of intellectual property rights originating from publicly funded research; whether performed by universities or companies, the involved institutions obtain in principle the right of ownership (for a more technical account, see Colsaet, 2005). This new legislation was an important stimulus for adopting and/or further professionalising intellectual property-related procedures and regulations. Together with the rise of science-intensive fields of economical activity (like bio-

Table 1. Overview of recent empirical studies on scientific and entrepreneurial activities of academic researchers (Based on Callaert, forthcoming 2009).

Source	Research Setting	Findings
Van Looy et al. (Research Policy, 2004).	Quantitative analysis of entrepreneurial (contract research) and scientific activities of professors at K.U. Leuven, Belgium (N = 167).	Entrepreneurial professors (involved in contract research) publish more than non-entrepreneurial colleagues. No skewing of publications towards the more applied spectrum. Positive relation between turnover of contract research and scientific advantage of contract researchers.
Breschi et al. (Revue d'Economie Industrielle, 2005).	Quantitative analysis of Italian inventors' patent and publication activity over time (N = 300).	Average publication productivity higher for inventors than for control group. Yearly observations: advantage already somehow exists before patenting event, but increases in the years immediately after the patent.
Meyer (Research Policy, 2006).	Quantitative analysis of publication and patent activity of nano-scientists in UK (13,235 authors), Germany (22,242 authors) and Belgium (2652 authors)	Patenting scientists outperform their non-patenting peers in terms of publication counts and citations received. Patenting scientists are overrepresented among star scientists, but their scientific advantage compared to non-inventing peers does not hold for the star scientist sample.
Van Looy et al. (Research Policy, 2006).	Quantitative analysis of patent and publication behavior of professors at K.U. Leuven, Belgium (N = 317).	Academic inventors publish more than non-inventing colleagues. Scientific advantage in the period after first patent has been invented is larger than in the period before. In general, inventors publish more in scientifically oriented journals than their colleagues who are not involved in patenting.
Azoulay et al. (Journal of Econ Beh. and Org, 2007).	Quantitative analysis of publication and patent activity of 3862 life scientists in US.	An increase in a researcher's publications significantly adds to the odds of this researcher to become an inventor in the following year.

Source	Research Setting	Findings
Calderini, Franzoni & Vezzulli (Research Policy, 2007).	Quantitative analysis of patent and publication behavior of Italian scientists over time (Material Sciences; N = 1276).	The probability to patent is a curvilinear function of scientific productivity, basicness and impact: increasing for low-to-moderate-high values of the variables, and decreasing for high values.
Crespo, M., & Dridi, H. (Higher Education, 2007).	Qualitative study of how UI relations impact academic research (in-depth interviews with five TT officers and 28 university researchers in Sciences, Engineering and Social Sciences (< 6 Québec HE institutions, Canada).	Researchers' involvement in projects with industry does not seem to influence the number and quality of publications. Scientific benefits are even reported from these partnerships. Benefits stem from adopting strategies in the negotiations with industrial partners (guaranteeing permission to publish), networking with other researchers in the same area.
Czarnitzki et al. (Research Evaluation, 2007).	Quantitative analysis of publication and patent activity of over 3500 German researchers.	Positive relation between patenting and publication quantity as well as quality.
Elfenbein (Journal of Economic Behavior and Organization, 2007).	Quantitative analysis of the relation between academic prestige and licensing outcome (1703 reports of patentable inventions by Harvard University faculty (N = 451).	Inventors' prior scientific output is positively correlated with the likelihood that their new technologies will be licensed. It is uncorrelated with the receipts generated by the licensed technology.
Stephan et al. (Economics of Innovation and New Technology, 2007).	Quantitative analysis on patenting and publication behavior of a cross-section of over 10,000 US doctorate recipients.	Patents are positively and significantly related to the number of publications.
Fabrizio & DiMinin (Research Policy, 2008).	Survey + quantitative analysis of patent and publication activity over time of US researchers (N = 400) in science and engineering disciplines.	Yearly average publication productivity higher for inventors than for non-inventors. Yearly number of publications increases following a patent. First patent not related to citations received afterwards, but negative effect of patent stock on citations received.

technology), the introduction of the Bayh-Dole act undoubtedly contributed to the strong increase of patenting activity undertaken by American universities from the 1980's onwards (Branscomb, 1999; Mowery et al., 1998; 1999; 2001). Indeed, when looking nowadays at patent activity undertaken by universities, the strong performance of American universities is striking. Table 2 provides an overview of universities, identified within the EPO patent system[8] who have created in the last years a patent portfolio exceeding 100 applications (published after 2000).

Table 2. Overview of most active universities within the EPO Patent System.

1	US	THE REGENTS OF THE UNIVERSITY OF CALIFORNIA
2	US	BOARD OF REGENTS, THE UNIVERSITY OF TEXAS SYSTEM
3	US	THE JOHNS HOPKINS UNIVERSITY
4	US	MASSACHUSETTS INSTITUTE OF TECHNOLOGY
5	US	WISCONSIN ALUMNI RESEARCH FOUNDATION
6	US	CALIFORNIA INSTITUTE OF TECHNOLOGY
7	US	THE BOARD OF TRUSTEES OF THE LELAND STANFORD JUNIOR UNIVERSITY
8	IL	YISSUM RESEARCH DEVELOPMENT COMPANY OF THE HEBREW UNIVERSITY OF JERUSALEM
9	UK	OXFORD UNIVERSITY
10	US	THE REGENTS OF THE UNIVERSITY OF MICHIGAN
11	UK	CAMBRIDGE UNIVERSITY
12	US	THE TRUSTEES OF COLUMBIA UNIVERSITY IN THE CITY OF NEW YORK
13	US	THE BOARD OF TRUSTEES OF THE UNIVERSITY OF ILLINOIS
14	US	TRUSTEES OF THE UNIVERSITY OF PENNSYLVANIA
15	US	UNIVERSITY OF FLORIDA
16	CH	ETH ZURICH
17	US	DUKE UNIVERSITY
18	US	PRESIDENT AND FELLOWS OF HARVARD COLLEGE
19	US	YALE UNIVERSITY
20	US	THE UNIVERSITY OF NORTH CAROLINA
21	US	CORNELL RESEARCH FOUNDATION, INC.
22	BE	K.U. LEUVEN
23	US	UNIVERSITY OF UTAH RESEARCH FOUNDATION
24	US	UNIVERSITY OF SOUTHERN CALIFORNIA
25	US	UNIVERSITY OF ROCHESTER
26	CH	ECOLE POLYTECHNIQUE FEDERALE DE LAUSANNE
27	CA	THE UNIVERSITY OF BRITISH COLUMBIA
28	US	UNIVERSITY OF PITTSBURGH
29	US	REGENTS OF THE UNIVERSITY OF MINNESOTA
30	US	UNIVERSITY OF VIRGINIA PATENT FOUNDATION
31	US	THE RESEARCH FOUNDATION OF STATE UNIVERSITY OF NEW YORK
32	US	NORTH CAROLINA STATE UNIVERSITY
33	US	UNIVERSITY OF MARYLAND
34	US	THE UAB RESEARCH FOUNDATION
35	US	EMORY UNIVERSITY
36	CH	UNIVERSITY OF ZURICH

Applications > 100, published from 2000 onwards.

As such, these figures suggest that adopting Bayh-Dole like legislative framework conditions might be an interesting option for European countries in order to further stimulate innovative activity. Economical theories on innovation provide additional arguments in this respect. The seminal work of Arrow (1962) already pointed out that within innovation market failures occur frequently. When one scrutinizes the nature of technology developed by academic scientists, it becomes apparent that these technologies are often of an embryonic nature, requiring additional investments to arrive at market applications (see Jensen, Thursby & Thursby (2003) for a revealing account). In the case no ownership rights exist, incentive issues arise, both on the level of the academic inventor and on the level of his/her principal (i.e. the university). Stated otherwise, if scientific inventors are not acknowledged as 'owners', incentives to engage in further development efforts are absent; the amount of follow up efforts – towards market exploitation – will be driven by voluntarism only. Granting IP rights on the other hand, creates entrepreneurial agency.

The next question then relates to who should acquire such rights, individual inventors or their principal (the university)[9]? Situating these rights at the level of individual inventors might result in under-investment due to risk averseness and/or the lack of capabilities to further invest in the development of the technology. In addition, if one leaves out universities conflicts of commitment might arise between agent and principal, with academic inventors pursuing technology development activities while universities limit their scope to education and research. Moreover, when situating these rights at the level of the university, it becomes feasible to address specific concerns that stem from the nature of scientific work (e.g. rules on disclosure, impact on science and education). Stated otherwise, such university specific regulations seem justified to guarantee the co-presence of multiple academic missions (Science, Education & Knowledge Transfer) and to avoid potential conflicts (including secrecy and skewing). Notice finally that granting rights to universities creates a more transparent 'market' situation towards industrial partners; being explicit on the level of terms and conditions not only seems fair from a funding perspective; it might also reduce transaction costs.[10]

While conceptual arguments might be advanced in favor of granting IP rights to universities, an empirical assessment of their impact seems as relevant. Currently, research on this issue is being undertaken within the Steunpunt O&O Indicatoren (see for a detailed account of the Flemish case, Du Plessis et al., 2006; for a European comparison, Van Looy, Meyer, du Plessis & Debackere, 2007/forthcoming). Part of the research activities addresses the question whether or not different legislative framework conditions coincide with differences in terms of the amount of technological activity undertaken by universities within a particular national innovation system. Table 3 provides an overview of the countries under study and the legislative framework conditions for the period under study (1990-2004). Notice that for three countries (NL, UK, France) university's rights are treated like rights of any employer within the jurisdiction of the country (so no specific Higher Education Institutes (HEI) legislation in place).

Table 3. Overview of countries under study – Impact of legislative framework conditions.

Belgium	The governance of Universities has become a regional responsibility (state reform 1991). In Flanders all IP from university researchers belongs to the university. A similar logic has been adopted in 1998 by the French Community.
Germany	Private and public employer has the rights to patent service inventions; at the same time university professors own the patent rights to university inventions (law on employee inventions 1994). 2001 Reform of Employee Law has rendered university inventions "service inventions" which means they now belong to the university.
Denmark	Act on Inventions at Public Research Institutions (2000) grants title to Public Research Organizations (PRO) but allows inventor right of first refusal. Before 2000 the rights were owned by the researcher/professor.
Finland	Employer has right to patent, also in the case of PRO. University inventions are notably exceptions: the patent rights belong to the employee (1967). Finland is currently changing its legislation (towards granting rights to universities).
Sweden	Professor's privilege.
Netherlands, France and UK	Three countries in which legislation is general, i.e. universities are considered as employers, which will own the rights on inventions made by staff.

Table 4. Impact of different legislative framework conditions on universities' technological activity.

IP Rights	**Mean**	**Std. Deviation**	**N**
Employee has right to patent invention	,4630	,72297	47
Employer has right to patent invention	4,9846	4,66603	17
General Employer Oriented IP	1,7193	1,45154	45

Source	**Type III Sum of Squares**	**df**	**Mean Square**	**F**	**Sig.**
Corrected Model	564,789(a)	13	43,445	26,520	,000
Intercept	15,105	1	15,105	9,221	,003
HERD	4,406	1	4,406	2,690	,104
GERD	,174	1	,174	,106	,745
Year	15,458	1	15,458	9,436	,003
IP Rights	41,105	1	41,105	25,091	,000
Country	174,400	6	29,067	17,743	,000
IP Rights * Country	68,486	2	34,243	20,903	,000
Error	155,630	95	1,638		
Total	1030,578	109			
Corrected Total	720,420	108			

R Squared = ,784 (Adjusted R Squared = ,754)

Table 4 reports the results obtained by applying a fixed effect econometric model (ANCOVA) where different legislation framework conditions act as independent variable. Business expenditures on R&D (BERD) as well as expenditures on R&D by higher education institutes (HERD) are included as control variables. The number of patent applications by universities figures as dependent variable.[11]

It becomes clear that specific HEI tailored legislative framework conditions have a significant and considerable impact on the amount of technological activity observed. Countries adopting such a legislation observe higher levels of technological activity compared to previous periods and compared to countries in which legislation opts for the professor's privilege (i.e. situating the ownership rights at the level of the individual researcher)).

Not only does one observe a notable difference compared to the countries which opt for professor's privilege; also the difference with broader, employer oriented, legislation is significant and outspoken. The logical next question then becomes whether the observed differences stem from shifts in technological activity – from one type of actor towards another, e.g. from individuals toward universities – or whether they reveal an overall net gain in terms of technological activity within the innovation system. Here the findings reported by du Plessis et al. (2006) are unambiguous for Flanders; the observed impact can indeed be interpreted as a net gain. Likewise, for the European countries under study, no crowding out effects have been observed; neither in terms of patent activity undertaken by individuals, nor in terms of patent activity undertaken by firms.

Given the net effect one hence observes in terms of technological activity, adopting legislative frameworks conditions that incentive universities and at the same time take into account the specific role of scientific actors, seems highly appropriate. Introducing on a larger European scale such 'best' practices might be more beneficial for the innovative performance of Europe than preserving the diversity currently present within Europe.

III. Conclusion

In this contribution, we highlighted the role universities can play within innovation systems. Two specific concerns have been discussed in more depth; the occurrence of unintended side effects that might jeopardize scientific activities, and the role of legislative framework conditions that might foster a more active role of universities in terms of technology development. With respect to the first point, it became apparent that reconciling scientific and technological activities within academia is feasible. With respect to the second issue, more technological activity is being observed when installing university (HEI) specific legislative framework conditions. The net effect of the observed impact even suggests that more technological activity within universities is not only feasible, it might even be desirable given the ambitions of Europe within the current, global, knowledge economy.

NOTES

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3. Innovative economic activities imply a process of cross-fertilization in which different knowledge domains are involved. Knowledge centers with a large variety of disciplines consequently have greater potential for cross-fertilization. By further developing this potential, they can greatly contribute to preventing the risks of technological monocultures.
4. During the first academic revolution (19th century) research became a part of universities activity profile.
5. One could even go back to the 19th century to explain the phenomenon of entrepreneurship at universities; see Hane, 1999; Kodama and Branscomb, 1999; Rosenberg and Nelson, 1994 for historical overviews extending longer time frames.
6. For a recent overview on this debate within the field of Medicine, see Kelch (2002); with respect to policies adopted in order to address potential conflicts of interest within this field, see Drazen and Curfman, 2002.
7. Centers that see improving industrial products and processes as part of their mission spend about 19% of their R&D activities on basic research, while university centers that do not consider this important devote about 61% of their R&D activities to basic research (Florida & Cohen, 1999).
8. Universities have been identified based on the sector allocation methodology developed by Steunpunt O&O Indicatoren, see Van Looy, B., Du Plessis, M. & Magerman T. (2006).
9. One could also envisage a situation whereby such rights are situated at levels above the principal of the inventors (e.g. a patent organization for a region or country as a whole). This would only make sense if economies of scale are important; these are however

limited (and relate to IP procedures). Moreover, by de-multiplexing relationships, new conflict situations (both within and between involved organizations) can and probably will arise like witnessed in the past in the both the UK (BTG) and the US (NRC); see for a revealing account on this issue, Mowery & Sampat (2001).

10. Whether it will actually do, will of course depend on the behavior of negotiating partners.
11. University owned patents are identified by means of the sector allocation methodology developed by Van Looy, Du Plessis & Magerman (2006).

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