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PATENT RELATED INDICATORS FOR ASSESSING KNOWLEDGE-GENERATING INSTITUTIONS: TOWARDS A CONTEXTUALISED APPROACH

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Patent related indicators for assessing knowledge-generating institutions: Towards a contextualised approach.

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Abstract

This contribution aims at examining the extent to which patent related indicators are relevant for shedding light on the notion of excellence within knowledge generating institutions. Traditionally, excellence has been looked upon as the ability to create interesting and valuable new scientific concepts, theories and data. From such a perspective, scientific excellence can be assessed through scientometric measures of publication output and impact. The recent interest in the 'entrepreneurial' phenomenon within knowledge generating institutes justifies efforts to examine the relevancy of broadening the set of indicators used to assess such institutions into the direction of entrepreneurial excellence. In this paper we will examine the relevancy of using patent data in order to delineate such additional, more entrepreneurial oriented, indicators. The arguments and findings presented in this respect will lead us to a plea for the use of these indicators in a contextualized manner.

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The changing nature of knowledge generating institutions: from 'ivory towers' to entrepreneurial actors?

From the mid-1980s onwards, one observes an increasing convergence among scholars of innovation and innovation policy regarding the importance and relevance of a set of complex interactions between different, institutional actors; these interactions are seen as constitutive for the process of knowledge generation and diffusion on a national or regional level (e.g. Freeman, 1987; Lundvall, 1992; Nelson, 1993, Nelson and Rosenberg, 1993). This idea, synthesized by the concept of 'innovation system', has been used as framework for designing innovation policies and adequate institutional arrangements aimed at fostering the genesis and development of innovation outcomes. Within this framework, knowledge-generating institutions, like universities and research laboratories, besides industrial public and private research laboratories (the dominant locus of R&D and innovation in most fields) and more recently, government agencies, are more and more seen as key players with respect to the innovative potential of any given region or society (e.g. Varga, 1998).

Hence, one witnesses a renewed attention for the interactions and network dynamics in general and more specifically in science-industry interactions; examples include the concept of scientific networks (Pavitt, 1997; Steinmueller, 1994; David, Foray and Steinmueller, 1997); the work on strategy, structural analysis of industries and competitors (Porter, 1995), and the vision on industry, academia and government interactions, encompassed by the 'Triple Helix' model (Leydesdorff & Etzkowitz, 1996; Etzkowitz & Leydesdorff, 1997; Leydesdorff & Etzkowitz, 1998; Etzkowitz & Leydesdorff, 1998).

Closely associated to the Triple Helix model, the notion of 'entrepreneurial universities' (Etzkowitz, 1998; Etzkowitz, Webster & Healy, 1998; Branscomb, Kodama & Florida, 1999) has increasingly been used in relation to the changes faced in recent years by academia. These relate to greater involvement in economic and social development, an increasing emphasis on the commercialization of research results, as well as managerial and attitudinal changes among academics with respect to collaborative projects with industry. As such, one can speak of a 'second academic revolution' in the 1990s, after the 'first academic revolution' that made research an inherent part of university's mission in the 19th century (Etzkowitz & Leydesdorff, 2000).

In fact, a multitude of elements have contributed to the diffusion of this entrepreneurial phenomenon. A phenomenon which in itself can be considered - at least in the US - as a logical extension of the successful engagement of university research in fields such as space, defence and energy during the 1940s, 50s and 60s[i]. Among these elements, shifts in federal funding (US), as well as changes in the tax treatment of R&D expenditures have been identified as important (Cohen et al. 1998). Moreover, a crucial dimension in the process of building-up academic entrepreneurial capacity relates to the adoption of policy measures that regulate intellectual property rights and related patenting and licensing activities. Well known regulations imply the Bayh-Dole Act and the Stevenson-Wydler Act in the US; while also in Europe, comparable arrangements become more widespread. These new regulations granted universities ownership of intellectual property arising from government-funded research and the right to commercialize the results. Such measures gave a significant boost to the adoption or further professionalization of IPR-related procedures and policies, while contract research conducted at universities became more and more looked upon as an inherent part of the routine activities of today's universities (Etzkowitz et al. 1998; Etzkowitz & Kemelgor, 1998; Van Looy, Debackere & Andries 2002, Branscomb et al. 1999). Finally, as Kodama and Branscomb notice, it should be recognised that the economic sectors with the most rapid growth are the ones that are closest to the 'science base': microelectronics, software, biotech, medicine and new materials. These growth areas are dependent on highly skilled people and the findings of the latest research; as such it should come as no surprise those universities and knowledge creating institutions find themselves in an advantageous position to contribute and participate in the growth of these very industries (Kodama & Branscomb, 1999). Hence, one observes to an ever-larger extent the creation and implementation of a variety of transfer-oriented arrangements. These include industrial liaison or technology transfer offices, academic spin-offs and joint ventures whereby universities start acting as a shareholder, science parks and business incubators. Such new arrangements reflect the enlarged, entrepreneurial oriented, role of research institutes.

The further diffusion of this entrepreneurial phenomenon in relation to knowledge generating institutes like universities and research centres also spurs the search for indicators that complement the traditional ones i.e. publications and citation rates, and that reflect this more entrepreneurial orientation. Traditionally, excellence has been looked upon as the ability to create interesting and valuable new scientific concepts, theories and data. From such a perspective, *scientific* excellence can be assessed through scientometric measures of publication output (Moed et al., 1995; Martin, 1996; Geuna, 1998) and publication impact (Tijssen, 1992; EC, 1997; Luwel et al., 1999; Verbeek et al., 2002). The recent interest in the 'entrepreneurial' phenomenon within knowledge generating institutes (Etzkowitz, 1998; Etzkowitz, Webster & Healy, 1998; Branscomb, Kodama & Florida, 1999) justifies efforts to examine the relevancy of broadening the set of indicators used to assess such institutions into the direction of *entrepreneurial* excellence[ii]. A multitude of indicators can be relevant in this respect (e.g. amount and nature of contract research, number of spin off companies), however, in this contribution we focus on the area of patents. Patents seem relevant, not only because they reflect technical inventions (novelty) with potential market value; but also because of the widespread availability of databases covering all technological fields, which adds to the attractiveness of the use of patent related indicators.

To what extent might patent data reveal the notion of 'entrepreneurial' excellence?

A patent, as Griliches (1990) put forward, is "*a document, issued by an authorised governmental agency, granting the right to exclude anyone else from the production or use of a specific new device, apparatus, or process for a stated number of years. The grant is issued to the inventor of this device or process after an examination that focuses on both the novelty of a claimed item and its potential utility. The right embedded in the patent can be assigned by the inventor to somebody else, usually to his employer, a corporation and/or sold to or licensed for use by somebody else. This right* *can be enforced only by the potential threat of or an actual suit in the course of infringement damages" (Griliches, 1990, pp. 1662-1663).* One of the qualitative properties that Grupp (1998) denoted in patents was that they grant to the owner the exclusive right of exploitation of a precisely defined technical knowledge for a specific period of time. This can indeed be considered the main function of a patent: to protect the inventor, to avoid technological knowledge from becoming public property and to avoid competitors from imitating and claiming new knowledge as their own. Inventors are granted a temporary monopoly situation, allowing them to sufficiently benefit from their inventions. As such, the economic rationale of the patenting system lies in the fact that patents stimulate innovative efforts, which in turn stimulates technological advance and economic growth (Verbeek et al., 2001). This function is also the core of Griliches (1990) definition. Three conditions for the grant of this exclusive right need to be fulfilled: novelty, quality and the possibility of being commercially applicable (Grupp, 1998).

As such, patents are a reflection of the creation of something 'novel'. This implies that they can be considered as the result of an effort to contribute and add to the existing knowledge and know-how within a certain environment. Moreover, patents granted have – at least potentially - an economic value: the invention proposed must be useful for application in one or other field. As such, the creation of a patent intrinsically implicates industrial relevance of the knowledge created.

Also with respect to the patent universe, reliable and comprehensive data sources are available, allowing for systematic and objective quantitative analyses. The elaborate and well-structured amount of information that is systematically stored in patent documents can be seen as the result of a second function of patents that was denoted by Grupp (1998): the information function, which manifests itself through publication of the patents. Any information in these publications can be used by others than the inventors, with the purpose of obtaining knowledge about the progress of technological knowledge.

This progress can be assessed – on the level of knowledge generating institutions – on different levels. First of all, patent counts can be used to assess the technological excellence of certain institutions in general, or within certain technology domains. Secondly, and similar to publication-related assessment practices, one can 'weight' patents by analysing the extent to which they receive references by future patents. Finally, one could argue that the extent to which patents are assigned to both research centres and companies (co-assignees) is a reflection of higher levels of industrial relevance (see also Tijssen, 2002). In this respect it should be noticed that looking at the inventor fields that are found in patents, rather than the assignee fields, might be relevant as well. When knowledge creating institutions that work closely with industry, decide to transfer the patent rights towards the industrial partners involved, no traces of knowledge creating institutions will be found within the assignee fields of these patents (for an illustration of the importance of this phenomenon, see Saragossi & van Pottelsberghe, this issue). Information on the involvement of these institutions is at that moment only to be retrieved by means of analysing the inventor fields, an approach more and more researchers are exploring this moment (for a recent example, see for instance Balconi et al. 2002). One should be aware that such an approach is only feasible when exhaustive overviews of scientific personnel are available from a third source, as the inventor fields within patent databases do not contain information on employer's association.

In addition, patents can be used for developing complementary indicators. Extensive documentation is captured in patent documents; such as the references to prior art (both technical and scientific) that served as a knowledge base for the creation of the patent (for an extensive overview see Verbeek et al. 2001, 2002a; for some concrete applications, see Narin et al. 1997; Tijssen et al. 2000; Verbeek et al. 2002b). Examining to what extent knowledge generating institutes have created prior art for patents, by analysing patent and scientific references within these patents, allows for an assessment of the extent to which these institutes have contributed to the genesis of novel technological artefacts, which can in turn be considered an aspect of the notion of 'excellence'. Table 1 summarizes the different types of indicators that can be derived from patent sources.

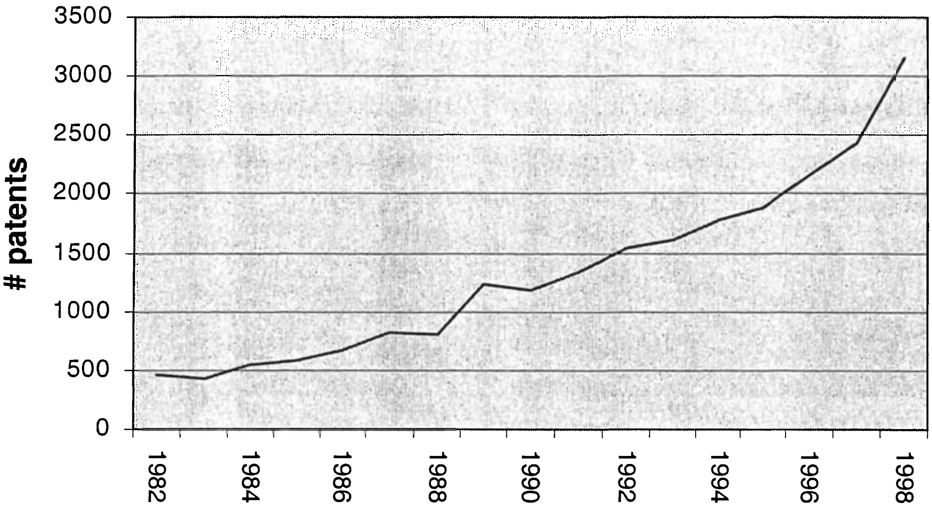
Table 1: Patent Related indicators – An overview

Patent Based Indicators that relate to the notion of 'Entrepreneurial' Excellence	
Patents	Citations within Patents
Number and range of patents assigned to or invented by staff members of Research Institutes Number and range of co-patents assigned to or invented by Research Institutes jointly with Industry Number and range of (co-) patents multiplied by an impact Index, i.e. a measure of how frequently an institution's patents for e.g. the previous five years are cited in the current year, relative to all citations within the system.	Non Patent References: Analysis of Non Patent References in order to define scientific publications and their source of origin (affiliation). Further analysis results in indicators of 'entrepreneurial' excellence in terms of 'scientific contribution towards technology development' Patent References: Analysis of Patent References in order to define their source of origin – patents cited and held by Research Institutes (or co-applicant) results in an additional indicator of 'entrepreneurial' excellence.

Using patent-related indicators: towards a contextualised approach

So, at first sight, one might be tempted to conclude that patent counts and their derivatives are straightforward indicators for illuminating the entrepreneurial capabilities of knowledge generating institutions, notably in the field of technology development. US data that have nowadays been made available on a regular base[iii] reinforce this impression. Like figure 1 depicts, aggregate statistics show a clear increase in patent activity for (US) universities. This increase exceeds overall patent growth rates, a phenomenon which has manifested itself from the 1960's onwards (Henderson et al. 2002, Mowery et al. 2002).

Figure 1: The evolution of university patenting in the U.S. since the Bayh-Dole Act in 1980 (data: 1982-1998) - *Based on: Science and Engineering Indicators 2002 (NSF)*



When turning towards the European research arena, things are however less straightforward. Table 2 summarizes the correlation between the share of patents held by Universities within different countries and the evolution of time for the last decade. At first sight, results might be perceived as in line with the observations found in the U.S. One observes a steady increase of the 'market share' of universities over the last 10 years for the majority of the countries to be found in table 2 (correlations). This is not an overall phenomenon though; notably for France, such a positive relationship is not to be found[iv]. Moreover, if one relates these results with absolute figures on the proportion of patents held by universities (last column of table 3), the variety of patterns becomes even more striking. For a number of countries, like United Kingdom as well as Belgium and The Netherlands, one witnesses an evolution of the share of patents held by universities towards 2/3%. As mentioned, such a growth phenomenon is completely absent in France. At the same time for Germany and Denmark, a positive trend is to be found, with absolute figures however which inspire one to conclude that university patenting activity is a very marginal phenomenon within these countries. This latter observation can be linked to the presence or absence of a specific legal and financial framework which defines the intellectual property rights of the actors involved (Meyer-Krahmer & Schmoch, 1998). For instance in Germany, during the period under study, professors could freely dispose of their intellectual property rights; keeping Universities to a large extent out of the picture in as far as patenting is concerned.

Table 2: Evolution of share of patents held by universities for different EC countries – Period 1991 – 2001

	Correlation (Proportion of patents held by Universities – Year)	Significance	Proportion of patents held by Universities 1991-1992	Proportion of patents held by Universities 2000-2001
Netherlands	0,692*	0,018	1,11%	1.94%
United Kingdom	0,956**	0,000	0,88%	3.30%
Belgium	0,748**	0,008	0,70%	2.39%
Denmark	0,777**	0,006	0,00%	0.23%
Germany	0,667*	0,025	0,07%	0.15%
France	-0,037	0,914	0,43%	0.37%

* p<0.05; ** p<0.01

So while the previous exposé on patent indicators might lead to a rather straightforward conclusion, i.e. that patent counts do reveal information about technology-oriented, entrepreneurial activities of knowledge creating institutions like universities and research centres, these results turn our attention towards a more fine-grained approach in which context specific elements need to be introduced in order to arrive at appropriate assessments.

Stated otherwise, when using such indicators to assess performance in terms of 'entrepreneurial' excellence, some serious caveats have to be made explicit. A first obvious remark relates to the idea that patent activity is to a considerable extent a field specific phenomenon. Previous research has shown that the propensity to patent varies heavily among sectors and technology domains. The recent work of Mowery et al. (1999, 2002) is a case in point. When examining the increase in patents held by universities, and more specifically, patent activity ongoing at Stanford and University of California, the authors conclude that the introduction of the Bayh-Dole actually had a modest impact; instead the most significant change at these universities, associated with increased patenting and licensing activity, is related to the rise of biomedical research and inventive activity. Hence, when comparing patent activity amongst different institutions, one should take into account the underlying differences that are related to specialisation within certain scientific and technological domains[v]. Universities with strong capabilities in domains that are characterised by a more modest 'propensity to patent' will wrongfully be assessed as 'less performing' than their counterparts that are active in fields characterised by higher levels of patent activity. It is clear that such differences should be labelled in terms of difference in 'specialisation' rather than as difference in 'performance' or 'excellence'.

In addition - and this point becomes increasingly important when extending comparisons or benchmarking exercises across national boundaries – specialisation does not limit itself to disciplines. One can also observe differences between 'national innovation systems' in terms of the role assigned to different actors. For instance, within France, a relative larger role in terms of knowledge creation, including technology development, is played by public research centres. Universities on the other hand focus relatively more on education compared to some other European countries, where universities play a more central role in research and technology development (e.g. Belgium, Netherlands, UK) vis-à-vis public research centres. As such, differences in policy decisions with respect to the role of several institutional actors will translate into differences in scientific and technological output. These differences should thus be taken into account especially when assessing institutions and comparing the technological output of different actors *across* the boundaries of such innovative systems.

Table 3 further clarifies this point. For several countries, the relative share of patents can be found, by type of institutions. The data stem from USPTO and cover the period 1990-2000. A visual inspection of the data reveals large differences between European countries. Performing a chi square test indeed reveals statistically significant results ($p< 0.0001$).

Table 3: Distribution of USPTO patents (1990-2000) by type of actor for a selection of European Countries. Source: calculations of the authors, based on the USPTO database.

	Belgium	France	The Netherlands	United Kingdom	Germany
Company	91.7%	79,96%	94,83%	91,77%	96,17%
Private Person	1.78%	1,24%	1,91%	1,06%	1,71%
Public Res. Institute	3.5%	13.16%	0.75%	2.19%	0,11%
University	1.67%	0.38%	1.21%	2.39%	0,08%
Administration	1.09%	0.3%	1.19%	2.54%	1,76%
Hospital, Foundation					
Other/unclear	0.27%	4.95%	0.12%	0.05%	0,18%
Total	100%	100%	100%	100%	100%
	(3770)	(34429)	(8428)	(24312)	(82252)

Likewise, differences in terms of the institutional arrangements - especially with respect to IPR - might affect the distribution of patents held by the different types of actors. The Bayh-Dole act has often been mentioned whit regard to the United States, but also in Europe, several countries have been adopting similar agreements. For instance, in Belgium and France, regulations granting universities the intellectual rights on research that was funded by the government, were adopted in 1995 and 1982 respectively. Countries like Italy and Germany on the other hand, are currently in the middle of adopting regulations that address university patents (see for instance Cesaroni and Piccaluga, 2002). The differences in these regulations will undoubtedly affect the extent to which different actors are willing to engage in patenting activity and/or the distribution of patents among different types of actors.

In line with the previous caveat, it should be kept in mind that also the institutional arrangements, installed by knowledge generating institutions, both with respect to IPR as well as technology transfer arrangements in general, might affect the results that stem from using patent counts as indicators for assessing their performance. Not only do we refer to the specific incentive structure at the institutional level (for an elaboration on the crucial role of incentive systems, see Debackere 2001); but also specific arrangements with respect to *organizing* technology transfer and valorisation activities deserve our attention here. Knowledge generating institutes can also locate their technology transfer activities within other organisations, and choose or choose not to become a shareholder in such an organisation. For instance, Oxford University (UK) considers the presence of ISIS Innovation, a company wholly owned by the University, as a key element within the infrastructure established to encourage technology transfer. Such arrangements have indeed contributed to obtaining the award of 'Britain's most innovative university' (in 2001), but they also complicate the interpretation of patent statistics: the University of Oxford is seldom found as assignee within the USPTO databases, leading to a ranking – based on mere counts - around place 35. However, adding to these figures the patents that are held by ISIS Innovation, makes Oxford University suddenly rank in the top 3 of universities.

Such arrangements can also take on the form of 'pooled' efforts. The presence of British Technology Group within the UK - which itself resulted from an integration of the National Enterprise Board and the National Research Development Corporation

(NRDC) – illustrates this phenomenon. The NRDC, was set up in 1948 to commercialise British publicly funded research and has been working with several universities and research centres over the last decades, to valorise the output of research taking place at these different institutions. Nowadays, both BTG and NRDC rank prominently within the UK patent statistics (BTG being within the top 10 of all UK assignees, calculations of the authors, USPTO data, period '90 – '00), but it is less clear from these statistics which patents stem from which research group and hence from which university or knowledge centre. This 'allocation' problem has inspired some scholars to start scrutinising the inventor fields – as opposed to the assignee fields – like they are found within patent files (e.g. Balconi et al. 2002). While this might sound as a logical practical step – although not without its practical complexities – such a decision should be situated within a broader reflection exercise aimed at identifying contextual elements which should be taken into account when delineating and interpreting patent based indicators.

Table 4 puts forward such a more encompassing framework. Both for patents and for citations within patents, contextual elements are summarised that should be considered when using and interpreting the delineated indicators. For patents, as argued above, these elements relate to taking into account disciplines and hence specialisation; the institutional environment which pertains to the way in which innovation systems have been designed and developed as well as the legislation regarding intellectual property rights; last, but certainly not least, the specific strategy and its translation into supportive – technology transfer oriented – organisational arrangements as adopted by knowledge generating institutions should be taken into account. Regarding references to be found within patents, it is clear that the considerations related tot specialisation hold both for patent and non patent (scientific) references. In fact, for the latter references, this seems to be the only relevant caveat; as there is an increasing international homogeneity to be observed with respect to the importance of publications[vi]. For patent references, similar issues can be raised as in the case of patents tout court; here also, heterogeneity on the level of national, regional and organisational arrangements should be taken into account when analysing and comparing institutions, especially when doing this across national boundaries.

Table 4: Towards the contextualised use of Patent Based Indicators

Indicators

Patents	Citations within Patents
▪ Number and range of patents assigned to or invented by staff members of Research Institutes ▪ Number and range of co-patents assigned to or invented by Research Institutes jointly with Industry ▪ Number and range of (co-) patents multiplied by an impact index, i.e. a measure of how frequently an institution's patents for e.g. the previous five years are cited in the current year, relative to all citations within the system.	▪ Non Patent References (NPR): Analysis of Non Patent References in order to define scientific publications and their source of origin (affiliation). Further analysis results in indicators of 'entrepreneurial' excellence in terms of 'scientific contribution towards technology development' ▪ Patent References (PR): Analysis of Patent References in order to define their source of origin – patents cited and held by Research Institutes (or co-applicant) results in an additional indicator of 'entrepreneurial' excellence

Contextual elements to be taken into account

▪ Specialisation (Resource availability within the different fields) ▪ Nature and characteristics of (national) innovation systems and task division among different types of actors within the system ▪ Technology Transfer Arrangements on the organisational level. ▪ IPR regulation on a national/regional/organisational level	▪ NPR & PR: Specialisation (Resource availability within the different fields) ▪ PR: Nature and characteristics of (national) innovation systems and task division among different types of actors within the system. ▪ Technology Transfer Arrangements on the organisational level. ▪ IPR regulation on a national/regional/organisational level

Conclusions

Within this contribution we started from the observation that the phenomenon of 'entrepreneurial' universities becomes increasingly widespread. This phenomenon inspires to examine the viability of broadening the notion of excellence; besides scientific indicators, one could argue for the relevancy of more entrepreneurial indicators. When examining the relevancy of patents in this respect, several observations can be made. Patent counts, including derivatives like weighted counts, co-patenting and the like, as well as citations to be found within patents, are more and more used to shed a light on the performance of knowledge generating institutions. While such an approach might be relatively straightforward for the US, which is characterised by a certain degree of homogeneity regarding the institutional context in which universities and research centres deploy their entrepreneurial activities, translating such an approach – including its benchmarking implications – towards the European research arena requires the introduction of contextual elements that allow for the appropriate use of such indicators. We have shown that considerable differences are to be observed between countries as well as institutions. Next, we have argued that these differences can be understood by taking into account the characteristics of the (regional/national) innovation systems in which these institutions operate; the degree of specialisation including the available resources of institutions; the arrangements regarding intellectual property rights to be found both on a regional/national and/or organisational level; and finally the specific strategy and its translation into supportive (technology transfer) arrangements knowledge generating institutions deploys. Both the use of patents and (scientific) references to be found in patents, requires taking into account these elements. As such, we defend the idea of using such indicators as long as they are accompanied by information that allows for a contextualised interpretation.

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[i] And can even be traced back to efforts and experiences situated in the 19th century, see in this respect for instance, Hane, 1999; Kodama & Branscomb 1999, Rosenberg & Nelson, 1994.

[ii] In fact, especially for universities, a third dimension of excellence, relates to educational objectives and tasks. As such one could argue that the idea of excellence in relation to knowledge generation institutions implies three broad categories or dimensions: scientific, entrepreneurial and educational.

[iii] E.g. the annual overview published by MIT Tech Review, based on figures and analysis conducted by CHI Research and the Association of University Technology Managers.

[iv] One could argue that more patents in France are held by Public Research Centres (like for instance CNRS) and hence that growth over time would manifest itself within these institutions. A closer examination reveals that this is not the case; on the contrary over the last decade Public Research Centres in France even seem to loose market share, a phenomenon the authors are currently investigating further.

[v] A critique one might utter with respect to the DEA study conducted by Thursby and Kemp (2002); here inputs have not been used in a disaggregated manner corresponding with the inputs for each field or discipline.

[vi] Atlhough one could argue that language differences might distort the picture to a certain extent.