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A baseline for the impact of academic patenting legislation in Norway

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As the commercialization of academic research has risen as a target area in many countries, the need for better empirical data collection to evaluate policy changes on this front has increasingly been recognized. This need is exemplified in the Norwegian case where legislative changes went into effect in 2003 expressly to encourage greater commercialization through patenting research results. This policy ambition faces the problem that no record of the patenting activity of academic researchers is available before 2003 when the country's "professor's privilege" was phased out. This article addresses the fundamental difficulty of how to empirically test the effect of such policy aims. It develops a methodology which can be used to reliably baseline changes in the extent and focus of academic patents. The purpose is to describe the empirical approach and results, while also providing insight into the changes in Norwegian policy on this front and their context.

Introduction

The commercialization of academic research is an important area of innovation policy in Norway as it is in a rash of other countries (see GEUNA & NESTA, 2003). Recent Norwegian legislation has removed the "teacher exemption clause" or "professor's privilege" and given higher education institutions a formal responsibility for commercializing patentable research results. This new legislation, which makes the

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question of the new role of academic research largely a question of patenting, is expected to substantially change the basis for commercializing academic research. An expressed objective is to increase the rate and degree of exploitation of the science base in Norway, thereby improving the basis for economic growth.

The controversial legislative change was accompanied by a set of expectations among policy-makers in Norway, as well as by an explicit obligation to monitor the effects of the change. Despite this, a viable way to assess the effect of the new measures was not envisioned when the new regulations went into effect in January 2003. A prerequisite is clearly to establish the extent to which academic patenting had taken place before the change, and in which fields, under what expectations etc. Establishing such a baseline is however problematic. No record of the patenting activity that preceded the change is readily available exactly because the "professor's privilege" regime placed patent-rights in the researcher's name: patents involving academic inventors are therefore difficult to distinguish from other domestic patents.

This paper addresses the need for an accurate ex ante account of public researcher involvement in patenting which can subsequently be compared with the ex post situation. It develops a registry-based procedure to identify academic inventions and to take stock of the patenting of researchers in public-sector research organizations (hereafter PSR). The intention is that such a baseline will allow comparisons over time, and potentially, across countries, and that it could become instrumental to informing the future development of this important innovation policy area. The paper will predominantly showcase the methodological approach and the results from the identification of academic patents. First the paper touches on some issues and perspectives and briefly surveys some relevant institutional and regulatory aspects. In the main section the paper presents some features of the approach before turning to the results, including, e.g., interpretation of the various types of "patent match", number of patents, technological fields and disciplinary differences.

Issues and perspective

It is well documented that the climate and the practice of academic patenting have changed dramatically during the past couple of decades. At the same time we recognize that the division between academic research, associated with "open science" and the ideal of "communalism", and the patent system, characterized by a technological focus and a commercial focus, has perhaps never been very clean cut. Some basic dimensions of academic patenting are worthwhile reviewing before we proceed to identify its recent history in Norway.

Schematic dimensions

Universities and colleges are seen as key actors or organisations in national innovation systems, not least because these organisations constitute vital infrastructure for the private research laboratories where many of the innovative activities are carried out (FREEMAN, 1987; LUNDVALL, 1992; NELSON, 1993). The frequently indirect nature of the relationship between universities and industry is emphasised – universities train industry personnel, create a pool of fundamental knowledge and, varying with discipline, engages in more direct contract work for private companies (ROSENBERG & NELSON, 1994). Increased direct interactions between universities and industry is often taken as an indication of a new form of knowledge production or a changed social contract for science (GIBBONS et al., 1994; GUSTON & KENNISTON, 1994; ETZKOWITZ & LEYDESDORFF, 2000; MARTIN & ETZKOWITZ, 2000; MARTIN, 2003). Policy-makers have pushed for such a development, including an increased focus on the direct commercialisation of academic research results (GODIN & GINGRAS, 2000; VAN LOOY et al., 2004). Through changed funding regimes and changed legislation regarding ownership of research results in many countries, policy-makers aim for a close "triple helix" relationship between universities, governments and industry (ETZKOWITZ & LEYDESDORFF, 2000).

Some are worried about these developments, based on a possible decrease in long-term research or changed research agendas, tensions between the culture of open science and increased commodification and commercialisation, and increased pressures on the researchers and the traditional teaching and basic research tasks they carry out (cf. SLAUGHTER & RHOADES, 1996; VAVAKOVA, 1998; GEUNA, 2001; NELSON, 2001; GEUNA & NESTA, 2003). This has been termed "drift of epistemic criteria" (ELZINGA, 1983) or "skewing" and "secrecy" problems (FLORIDA & COHEN, 1999). On the other hand, it has been argued that universities may strengthen their traditional norms and their research and teaching activities as a "second academic revolution" leads them into becoming "entrepreneurial institutions" with closer and more productive relationships with industry and the public sector (cf. CLARK 1998; ETZKOWITZ, 1998; ETZKOWITZ & LEYDESDORFF, 2000). Instead of being a question of either/or, successful universities and university researchers manage to combine academic excellence with industrial contacts and/or entrepreneurial contributions (GODIN & GINGRAS, 2000; VAN LOOY et al., 2004).

What is lacking to test many of these claims, models and theories is a firm empirical base. There are admittedly good sources for funding and publications in public sector research organisations, but fewer and often much poorer options when studying patenting. Earlier investigations focusing, e.g., on the relationship between funding, commercial and academic outputs, have had to rely on crude self-reported measures of patents and other commercial results (VAN LOOY et al., 2004; GULBRANDSEN &

SMEBY, 2005). Our methodology and resulting database for identifying academic patents and patent inventors may be one important piece to fit into this larger conceptual and tension-filled puzzle.

Growth accounting for academic patenting

The commercial logic of applying for a patent – as well as a certain cultural factor – has traditionally made patenting the domain of industry. Patenting is typically biased towards the applied nature of new technical knowledge. On its side, it can be said that "basic research" is typically biased against the idea manifest in the patent regime, that knowledge can be owned by someone and that others can be excluded from using it. Thus a more fundamental obstacle dividing university-research from patenting has been cultural. Such attitudes may have contributed to a situation in which patent-protection has not been carefully considered in all but special cases.

But even in cases where the basic science of university research does meet patentability requirements, an economic incentive is needed to outweigh the costs associated with patent protection. Since, "the outputs of basic research rarely possess intrinsic economic value," (DAVID et al., 1994) and since the traditional research university is not geared to developing and marketing any technological innovation that might arise, patenting has most often not been considered generally relevant for the fundamental research of universities and other non-profit R&D institutes.

On top of these two fundamental factors, a practical set of reasons has kept academic research from seriously considering patent-protection as an option. A lack of clear guidelines for university patenting combined with a lack of practical support in effectively managing "intellectual property" (applying for and capitalizing on patented inventions) has made the prospects of recouping the investment in the patenting process remote indeed for university research. Although a piece research may be patentable (or otherwise commercializable), the higher education institution has had few incentives for pursuing this in centralized European university systems like the Norwegian one where funds are largely distributed based on student numbers and where the researchers own the intellectual property rights.

This schematic division between patenting and academic research has of course never really been accurate. Instead academic research has long been associated with increasing innovation in the economy. Internationally, patenting of academic knowledge and concerted measures designed to promote commercialization of academic research both trace back to the early part of last century (MOWERY & SAMPAT, 2005; MOWERY & ZIEDONIS, 2002).

In Norway, there is also a legacy that substantially predates the new legislation. In a survey among academic personnel in Norway in 2001, seven percent of all university researchers in Norway stated that their research at one time or another had led to patents

(GULBRANDSEN & SMEBY, 2005). Also a recent interview study among Norwegian entrepreneurial professors indicates that patenting is relatively common in academia, although somewhat "hidden" as the institutions have played a miniscule role in the process and have had no routines for registering commercial outputs (GULBRANDSEN, 2003). Patenting and commercialization has largely been the arena of individuals, of academic entrepreneurs (MEYER, 2003a, 2003b; MEYER et al., 2003). Famous Norwegian researchers like physics professor Birkeland and chemistry professor Ugelstad combined basic research with patenting. Birkeland gained world recognition for his explanation of *aurora borealis* at the end of the 19^{th} century, and had his name on no less than 58 patent applications during his career at the University of Oslo, which has named its TTO after him. Danish data furthermore indicate that university researchers may relatively often be listed as inventors in patents granted to industry (VALENTIN & JENSEN, 2003).

Nonetheless the intensity of academic patenting has by all accounts changed in the course of the past decade or two. Qualitatively, the base-line of what is being patented is widening. Corporate and university patenting is each stretching what is patentable both in the direction of applied and basic science. There is growing overlap of university and corporate patenting, increasingly through collaborations between them (TRAJTENBERG et al., 1997). Simultaneously, increased patenting can be observed in the realm of basic science (incidentally, where both universities and corporations are active, often in tandem) but also in the other direction through an apparent weakening of the non-obviousness criterion (JAFFE & LERNER, 2004).

Quantitatively, a gathering set of studies have shown the increase of academic patenting especially in the US (see in particular MOWERY et al., 2004). HENDERSON et al. (1998) showed that academic patents increased 15-fold between 1965 and 1988.[1] This increase in intensity is recognized to involve a set of interlinking changes, including changes in the roles of universities (GIBBONS et al., 1994; WEBSTER, 2003; ETZKOWITZ, 1998; ETZKOWITZ et al., 2000), changes in technology (MOWERY, 2004), and, relatedly, changes in the patent-system (JAFFE & LERNER, 2004). Legal, regulatory and, not least, institutional elements all contribute to a climate for increased interaction between academic knowledge bases and those in the economy otherwise. MOWERY and colleagues (2004) argue that academic patenting is not a new phenomenon, but that it goes back much further than the Bayh-Dole Act of 1980. Whole industries, with semiconductors, computers and biotechnology as famous examples, have their roots in investments in public sector research, and this is also the case with earlier industries

[1] The explosion of university patents however has accompanied a peaking of this quality-measure during the mid-80s, suggesting, "that the rate of increase of important patents from universities is much less than the overall rate of increase of university patenting in the period" (HENDERSON et al., 1998).

like petroleum engineering and petrochemicals. In general, the enormous federal investments (and increases in these investments) constitute a central explanation for the academic patenting in the U.S.

Regulatory and institutional context

Academic research makes up a large component of national research efforts in countries like Norway. Policy interest in quickening the return to society from it is by no means new however. Policymakers began to see it as “an underutilized resource” in the 1980s (MARTIN, 2003), for which there was a rising tendency to ‘adopt appropriate policies’ (STANKIEWICZ, 1986). Since then, more and more countries have been occupied by concerns to (continue to) improve the climate for commercializing university research, and by concerns to improve links between public research institutions and industry. Particularly during the 1980s, the funding climate of higher education changed, and important new disciplines grew rapidly like biotechnology and ICT. Some countries also changed their laws with the Bayh-Dole Act of the U.S. setting an example for many other countries.

Inspired by Bayh-Dole and after many years of discussion, new legislation went into effect in Norway in 2003 that substantially changed the basis for commercializing academic research. The measure effectively removes the “teacher’s exemption”/“professor’s privilege” from the legal corpus and places the responsibility for commercialization of academic research on the universities. Legislative changes (most of them quite similar) can be seen in a number of countries, e.g. Denmark, Germany, the Netherlands, Italy, Finland and France.

The linchpin of the formative Norwegian policy takes the form of two amendments. The general objective to increase the rate and degree of exploitation of the science base, in order to improve the basis for economic growth:

- Proposition No. 40 to the Odelsting (2001–2002): Amendment to expand the societal responsibilities of universities and colleges to include promoting the practical application of research methods and results, not least in industry. Although the responsibility adheres formally to *patentable research results* only, the Ministry of Research and Education has specified that the higher education institutions also should deal with commercializable results that cannot be patented.
- Proposition No. 67 to the Odelsting (2001–2002): Amendment to increase the commercial exploitation of inventions by revoking the “professor’s privilege”. A division of income with one-third each to the individual(s), the department and the institution was suggested. The researcher still has a formal right to publish scientifically, even if this would make patenting or commercialization impossible.

- Adaptation of the institutional framework (TTOs, new seed-funding, adjustments of funding mechanisms, etc.). All the Norwegian universities now have set up TTOs, largely based on extraordinary government funding. New seed funding is expected to be set up in late 2005 in the university cities.

With the new legal amendments, the policy-makers hope to increase commercial utilization of academy-based inventions. An important point is that it intends to do so while maintaining the academy's traditional goals, namely free-research and higher education. In fact, the expressed intention is to strengthen the traditional goal of universities in spreading research results to society. To do so, the amendment substantially readdresses the role of academic research. It widens the interpretation of the university sector's obligation to disseminate research results to include commercialization as a channel for such dissemination. In order to do this the amendment changes the right to industrial application/commercialization of 'inventions' formally from the researcher to the university sector institution. The legislation about intellectual property rights is therefore now the same in all public research organizations, as there has not been a "professor's privilege" in the university hospitals or the research institutes. This was a central motivation behind the legislative changes, as different IPR legislation complicated commercialization processes in which researchers from different public organizations were involved.

The change imposes new obligations on the researcher and the university. In the new environment, researchers are obligated to orient the university about results with potential industrial application ('notification obligation'). The university has to respond within 4 months to this notification, and if the response is negative (the university does not claim the rights), the researcher may patent or otherwise commercialize without the institution's involvement. If the university accepts the property rights, it now has a formal obligation to try to commercialize the idea in question. Financial incentives may be on their way as well, as university funding processes are increasingly based on output indicators, which may include patents sometime in the future.

The recent international spread of initiatives that focus on increasing the rate and degree of exploitation of the science base brings with it a recognized need for better empirical tools to evaluate. The need for a robust and reliable empirical basis on which to assess commercialization practices over time and across countries was indeed the basis for recent OECD work on the licensing and patenting of public research organizations; the need for continued effort in this direction was also one of the work's major recommendations (OECD, 2003). The international policy environment continues to be characterized by a state of flux in spite of the experience already amassed and in spite of attempts to coordinate the direction of policies. In this setting, there is no doubt that there is pronounced, "need for timely and accurate information on the nature and extent of research collaboration between universities and industry, and on how it varies across discipline, type of university, sector, firm-ownership and time" (CALVERT & PATEL, 2003).

Approach and methodology

The methodological aim presented in this paper addresses this need for empirical information. The paper is designed to identify and analyze the involvement of academic researchers in patenting with an eye to creating a baseline which will allow comparisons over time, and potentially, across countries. This empirical analysis will be instrumental to informing the future development of this important innovation policy area. The approach identifies the involvement of academic researchers in domestic patenting by linking researcher-registry data with concurrent domestic patent data. This creates the basis for a targeted survey which will be used to evaluate the database match. The principle objective is to develop empirical tools to better analyze the changing role of public R&D in economic growth in a country where one will rarely, if ever, find the name of a higher education institution in a patent application.

The rash of legislative changes internationally has coincided with increased interest in the nature and extent of academic patenting. During the past few years, several studies have focused on different aspect of academic patenting (BALDINI et al., 2006; BALCONI et al., 2004; BASSECOULARD & ZITT, 2004; DU PLESSIS et al., 2005; MEYER, 2003A, 2003B; SAMPAT & NELSON, 2002; SAPSALIS et al., 2005; SCHMOCH, 2004). The combined approach we present here contributes to the identification of academic patenting and its analysis in this area.

General challenges and approaches

A set of challenges must be overcome in order to identify patents stemming from the research of public-sector institutions, especially universities. In a 'professor's privilege' environment, the patent record will generally not provide the indication of the inventor's institutional affiliation: the academic patent will tend to reside in the name of the researcher and/or a sponsor. In this situation patented results of academic research will initially remain invisible in the patent data.

Different strategies have been developed in such an environment (such as Finland, Italy, Germany, and Belgium) to identify cases where the population of PSR researchers overlaps the population of inventors. These have faced a common trade-off between the limitations of existing data and the considerable effort to identify academic inventors from that data.

Absent special circumstances,[2] running the names of 'academic' researchers against inventors in the patent record forms the only route towards identification. This approach provides the benefit of full information about the patenting activity (frequency, technological orientation, collaborators etc.). DU PLESSIS et al. (2005) for example link EPO patent applications and granted patents (1978–2001), granted US patents (1991–2001) and personnel data of the Flemish universities for 1990–2000. However this approach of course assumes the availability and reliability of name lists (preferably linked to institutional affiliation and other information) over a substantial period of time. This temporal dimension is important since the patenting event and the researching event are sequential, with the former activity tending to extend considerably backwards in time. In pursuing networks of inventors, BALCONI et al. (2004) for example used a list of professors at Italian universities for a given year (2003) and matched it against 1978 to 1999, then confirmed by a direct contact. The approach as a result underestimated the total population.

Moreover, the name-link approach risks generating large numbers of false-positives and of false-negatives for example due to the same-name problem (e.g. John Smith) or due to propensity for orthographic problems. These problems are compounded in countries like Norway which have standard name-forms (such as Hansen, Iversen, Gulbrandsen…) and atypical character sets (æ, å, ø) which may be error-prone in database programs.

The main alternative strategy is to systematically survey academic researchers on their patenting activities or to survey patent inventors on their affiliation. The Patval project (http://www.zew.de/en/forschung/projekte.php3?action=detail&nr=469) for example surveyed the inventors on samples of EPO patents in a number of European countries. This survey was not designed to identify academic inventors but does address the question of academic affiliations in its sample. An alternative approach has targeted public research affiliation among assignee addresses to identify academic patenting. It does so at the expense of excluding the considerable number of university invention filed for either by collaborating companies or private persons (SAPSALIS et al., 2005; SAPSALIS & POTTERIE, 2003; SARAGOSSI & POTTERIE, 2003).

In general, survey-based approaches, where successful, have the strength that they provide contextual information that is valuable to understanding the purpose, orientation and context of the researchers' patenting activity. On the other hand it relies on the researcher's own account of the patent particulars (such as the patent numbers, IPC classes, etc.) which opens up some initial difficulties. Furthermore, it again assumes current addresses of researcher that preferably includes additional information to avoid overburdening the respondent. Securing reliable responses for a representative set of researchers poses many challenges especially in larger countries with large and

[2] Such as the existence of periodic reporting (e.g. through national surveys) efforts which includes relevant questions.

diverse researcher populations. Moreover, there are a set of daunting trade-offs. These include the trade-off between selection criteria and representativeness and between the amount of information in the questionnaire and the critical question of response-rates.

Registry-data and a three-stage matching procedure

In this way, the identification of academic patents has tended to take two basic routes: either to identify inventors among available lists of PSR researchers or to identify PSR researchers from among available lists of inventors. Likewise, two basic strategies have been employed: one utilizing a survey-based strategy and the other relying on data-based matching procedures. These approaches tend to focus on general estimates of academic patenting designed as input to other theoretical discussions.

Our objective is rather to create a baseline to calibrate the extent and orientation of academic inventions at the transition of a new legislative regime. Here it is important to establish specific relationships between research-environments and patenting activity. It is therefore important not to introduce assumptions that will systematically overestimate or underestimate academic patenting. Special pains have therefore been taken to verify the identification while assembling information that may be important to analyze future changes in academic patenting.

The general approach is based on project which addresses the patenting of academic and other public sector researchers in two main rounds. In the first, the overall project links registry data covering all researchers in Norway with concurrent domestic patent data. This step affords the opportunity to identify and analyze the involvement of academic researchers in patenting. Furthermore it lays the basis for a targeted survey to explore qualitative aspects of commercialization, including attitudes, motivations to patent, the role of support services, etc. Stage two of the project surveys researchers identified in stage one. The second round serves both to provide qualitative interpretative information about academic patenting (reported in GULBRANDSEN et al., 2005) as well as to help verify (and revise) the accurateness of the identification exercise. The identification and the complementary survey can then provide a baseline against which to monitor and analyze Norwegian developments in academic patenting.

In the following we present the three-stage approach we developed in that project designed to identify PR inventors and their patents. A previous two stage approach corresponding first to the identification-procedure and then to the survey ran into the difficulty of dealing with non-responses in the survey verification stage. (IVERSEN et al., 2005) This paper introduces a further step to verify links.

The data

Our procedure relies on the unique combination of two registry data which together provides full count data over inventors and of researchers. The patent-data is taken from all patents applied for at the Norwegian Patent Office (NPO) and includes front-page information. The Researcher Register includes all researchers working in universities, colleges or in the country's extensive research institute-sector and is updated on a yearly basis for use in official Norwegian statistics.

The Patent Data includes full first-page information including the inventor and assignee names, addresses, patent-classes, and more. The patent register is based on 7,780 domestic patents,[3] involving a total of 6,590 different inventors.[4] All in all, these 6,600 individuals were involved 11,884[5] times in the 7,800 domestic applications. The patent data, encompassing 7,781 patents in total, was linked to the unique registry of researchers using the names and addresses of the researcher with the names and addresses (zip-codes) of patent inventors/assignees.[6] The correspondence between the researcher's area and the technological area of the patent was also used[7] at this stage to identify possible false-positives.

The Researcher Register covers on an annual basis all researchers in universities, colleges, and institutions receiving public funding. The information includes details of institutional affiliation and position, in addition to the names and addresses. This data allows us to avoid the problem faced by for example BALCONI et al. (2004) whose approach underestimated the number of academic inventors.

The researcher registry reflects a yearly average of 25,728 researchers in positions at the various UIH institutions. The composite picture based on 1997, 1999, 2001, and 2003 runs to 51,000 separate observations, since it captures turnover both in terms of researchers and the positions and institutions they are employed at. Twenty-one percent (10,615) of these observations were in the institute sector and the rest (39,881) were in the University and College sector. In cases where researchers change positions/affiliations in the time-frame, the latest one is used.

Stage 1 starts the identification of researchers from these public research organizations in domestic patenting by linking researcher-registry data with concurrent domestic patent data. The patent data centers on domestic patents that involve

[3] These are applications with a Norwegian address in the inventors and/or the applicant fields. These applications make up twenty percent of the total volume of patent-application (38,225) received by the Norwegian Patent Office during the six-year period (1998-2003).

[4] A unique key is given to individuals by the Patent Office. It is fairly accurate but contains some duplicates. Unifying this key among the sample reduces the total from 6,684.

[5] Five additional occurrences of inventors are without any information and therefore dropped.

[6] The postcodes were associated to county and district-levels via the Norwegian Post's database.

[7] The primary IPC classes of the patent applications were associated to Technological Areas by a widely-used Correspondence Key: the INPI/OST/ISI Key, Version 3, also used by BALCONI et al. (2004).

Norwegian inventors[8] that were applied for at the Norwegian Patent Office in the period 1998–2003. The first five years of the period thus involve patenting under the 'teacher's privilege regime', while the last will reflect the first affects of the new legislation. The choice of time-frame is one of many tradeoffs between taking stock of patenting activity over a longer period of time on the one hand, and lowering the response rate of the researchers surveyed in the next stage on the other. A five-year baseline is assumed to provide sufficient time-span in which to establish the extent and the orientation of academic patenting preceding the change in law in a way that can be compared to the patenting activity after the law takes affect. We found no reason to assume that a longer period would provide a more accurate picture of the situation before the change.

The match was conducted on the basis of names (last names and first names), addresses, and technological areas of both the patents (see footnote) and the research area of the specific research entity of the researcher. The process was an iterative one which essentially involved striking a balance between false negatives and false positives in view of both sets of information. A sequence of operations was undertaken whereby direct links were followed by same names/different addresses where the patent subject and the particular research group of the researcher were consistent. With reasonably clear cases established, further iterations looked into similar names initially excluded due to slight differences in the presentation of names (the variable use of middle names, orthographic mistakes, etc.). Uncertain cases with regard to names and addresses were also manually checked (different sources including the online phonebook).

Stage 2 starts from the list of 809[9] researchers that resulted from the previous stage. In addition to more straightforward links, this list includes a small set of grey cases in order to avoid false-negatives: these included name-duplicates and other cases where allowances were made as to spellings and addresses. This created the basis in a second stage for a targeted survey. The survey was first and foremost designed to establish baselines for motivations, tendencies, concerns, and other more subjective data which may be affected by the change in regime and which will be valuable to compare in future iterations. This dimension of the baseline is presented elsewhere (GULBRANDSEN et al., 2005).

The survey also had a valuable secondary purpose which we focus on here, namely to confirm the identification of academic inventors in the database match. Removing further duplicates, the survey encompassed 801 researchers. Of these, 316 (40%) provided complete responses, while a further four percent indicated that they were involved in a patent but disputed its relevance on other grounds.[10] Nine percent of the population (73) explicitly denied involvement (66) or returned the survey without

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[8] That is, inventors with a Norwegian address regardless of the nationality of the applicant.
[9] After several initial duplicates removed.
[10] For example, that it was the result of another affiliation.

comment. Taking into account other surveys that were returned without reaching the intended researcher (e.g. moved), this left 266 or 33% of overall non-response.

Stage 3: An affiliation networks approach was introduced to address non-responses. The second round of verification by survey provided the basis to deflate the false-positives towards a more accurate population but left a large proportion of unresolved cases. A third stage was therefore developed to resolve the 266 cases left open by the last stage. In this iteration, we opted not to estimate based on the positive and negative responses at this stage so as to maintain as far as possible a one to one relationship between individual researchers and specific patent-information. Therefore we plugged in the output of the survey against the patent-data and looked for two types of relationships between the unresolved category and signs of PSR affiliations either at the level of (i.) the patent-assignee or (ii) co-inventors.

This approach follows the logic of the "affiliation networks approach" which BALCONI et al. (2004) used to study 'networks of inventors'. This approach demonstrates that 'connectedness' of actors (inventors) are demonstrated via co-invention in groups of patents. Co-invention points to underlying cognitive relationships which indicate direct links between the actors. We therefore look for combinations between researchers who responded to the survey in patents with other researchers who did not. The direct link between co-inventors, combined with the original linking procedure, indicate quite clearly that the identification of the non-respondent was non-random.

These cases confirm the participation of the researcher in patenting and are thus classed as 'Collaborating Inventor Confirmation' (below). There remains the question of whether this patenting activity is linked to the researcher's activities at the public research organization. Here we assume affiliation on line with those who responded in the survey that they were involved in a patent but disputed its relevance on other grounds. This approach allows us to confirm a total of 87 researchers not confirmed in Stage 2.

A further 118 researchers left unconfirmed in the last stage are confirmed by looking at the link to the assignee. These involve cases where the assignee is either a public research organization itself or closely linked to a PRO, such as through a TTO or a science park. An additional number of spin-offs which either list a PSR address and/or feature high proportions of co-inventors are also tallied here: 13 such researchers are included here.

This three-stage approach thus confirms that a total of 569 researchers from Norwegian public research organizations were involved in at least one patent application in the period of 1998–2003. These researchers are involved in 10-11 percent of domestic patent applications, which we will examine in the next section. There remain a further 154 unresolved cases after these stages. In future, a more aggregated study could in a further stage estimate the likely proportion of confirmed researcher-inventors among this population.

Results

The three stage identification procedure distinguishes between seven categories, four of which provide a qualified verification of the link. Overall we distinguish between inventors and their patents that show an affiliation with public research organizations (Confirmed), those that rejected the link in the survey (Rejected), those that cannot be confirmed (Unresolved), and those with no apparent link (Others).

Table 1 shows the breakdown[11] of these categories by inventor, by patents (both fractional counts of inventors and the total number of individual patents involved), and by the total number of times the inventors appear on patents (frequency). It indicates that 71% (or 569) of the original 800 survey recipients have been confirmed in this iteration. These confirmed public research organization researcher-inventors make up 8.6% of all inventors in the period. Nearly 10% (828) of all Norwegian patents in the period involved at least one public research organization researcher. PSR patenting accounts for 12% (1,437) of the inventive activity in the Norwegian patent record.

Patenting and public research organizations

The following tables and figures explore general dimensions of public research organization patenting. The purpose is to lay the basis for further analysis of main dimensions of this activity. This explorative exercise will into the breakdown of academic patenting by technological area and by the subcategories of the PSR sector. In addition the grant-records will be briefly considered.

A total of 828 patents – or 10.6% of domestic patents – involves at least one PSR inventor. A fractional count compensates for the variable number of inventors per patent by dividing the patent among contributing inventors. This unification process reveals that the inventor contribution of university inventors is 4.4%, college inventors 0.6% and research institutes 3.2%, or a (fractional-based count) total of 8.2% for all public research organization inventors.

[11] The approach was significantly modified since a previous version: IVERSEN et al., 2005. In addition to the introduction of new categories discussed below, this presentation differs from the previous version of the paper in the number of Survey Confirmations, from 313 to 316. The change includes the inclusion of 2 respondents who filled out the survey without confirming their participation in Norwegian patenting. One of these ambiguous cases accounts for over 60 single-inventor patent applications. The present approach also includes two late responses not included in the last version, including a positive response.

Table 1. Norwegian inventors and patents by survey-based categories, 1998–2003

Category	Code	Description	Inventors	Patent 1 fractional counts	Patent 2 individual case	Patenting frequency
Public sector researchers[a]	**10-15**	**Confirmed**	**569**	**635**	**1085**	**1437**
	10	Survey confirmation[b]	316	402	613	783
	12,15	Applicant-based confirmation (PSR)[c]	131	119	222	351
	13	Collaborating inventor confirmation[d]	86	79	175	223
	14	Other affiliation[e]	36	38	75	80
Unresolved	**20, 25**	**Unresolved**	**154**	**150**	**228**	**239**
	20	Moved	44	42	66	66
	50	Non-response	110	108	162	173
Negative	**30, 21, 60**	**Rejected**	**77**	**88**	**142**	**145**
	30	Survey rejection	65	74	123	126
	21	Researcher unknown	12	14	19	19
Others	**60**	**Other inventors**	**5790**	**6908**	**7197**	**10063**
Totals			**6590**	**7781**	**7781**	**11884**

Source: Norwegian Patent Office-Inventor (Nifu Step), Norwegian Researcher Registry (Nifu Step).

[a] Since information in a given patent helps in some cases to categorize the inventor (see stages described above), a researcher may be found in different subcategories. In this situation, all patenting of that researcher is re-assigned to the lowest category found (code 11, 12, 13 etc.).
[b] Full survey response confirms identity. Duplicates are removed from patent-list. The result include 2 full responses who do not confirm link to Norwegian patents (64 patents involved in single case).
[c] The patents-assignee is a public research organization or directly affiliated (24 patents – involving 13 inventors – are the products of start-up companies with obvious PSR links).
[d] Fellow inventors are confirmed PSR researchers, suggesting that this also goes for the unresolved researchers in those patents.
[e] Survey response indicates that the inventor is the PSR researcher, but that the patents in question involved another position (for example after the respondent left the PSR sector).

Public research organization invention however varies strongly across technological areas. A focus on the total number of times confirmed PSR researchers were involved in Norwegian patents relative to other Norwegian inventors illustrates this. It also allows us to compare our results with the basic data used in BALCONI et al. (2004) who use the same technological categories for frequencies of academic patents over the total set of Italian patents registered at the EPO.

BALCONI et al. (2004), who underestimate the academic inventions, report that the frequency of academic patenting in Italian patents is 3%. Table 2 demonstrates that 6.8% of Norwegian domestic patenting (number of times academic inventors were listed as inventors in Norwegian patents relative to the total) involves inventors either from universities or colleges. Nearly 21% (versus 12% in the Italian study) of chemical and pharmaceutical patenting in Norway involve academic researchers and 11.5% of medical technologies and other Instruments. Thus these strong results serve to confirm SCHMOCH's (2004) observation that PRS inventors play a major role in certain science-based technology areas.

Table 2. Confirmed PRO inventors, frequency count by sectors of inventors in Norwegian patents-applications and corresponding percentages: 1998–2003

Patenting areas	Academy	Institution	Total	% UC	% INST	PRO %
Chemicals & pharma	364	143	1737	21.0	8.2	29.2
Instruments	171	170	1485	11.5	11.4	23.0
Electronics[a]	124	64	1602	7.7	4.0	11.7
Process engineering	48	78	1802	2.7	4.3	7.0
Mechanical engineering	96	168	4300	2.2	3.9	6.1
Consumer good	4	6	935	0.4	0.6	1.1
All fields	808	629	11884[b]	6.8	5.3	12.1

Source: Norwegian Patent Office-Inventor (Nifu Step), Norwegian Researcher Registry (Nifu Step).

[a] Includes 64 patents registered under Academy that are uncertain. See footnote above.
[b] A total of 23 (1 among academic inventors) did not link to the technological classification.

Table 2 also demonstrates that academic and research institution patents have distinct profiles in Norway. Whereas the contribution is remarkably similar in the field of Instruments, the contribution of the institutional sector is greater in the mechanical and processing fields (which include petroleum technologies).

Trend over time: An average of 10.7% of Norwegian patents involved at least one public research organization researcher in the five years leading up to 2003. In 2003, when the new law to promote academic patenting unexpectedly took effect earlier than expected, the proportion of academic patents in fact dropped considerably in 2003 to 10.3%. Although our baseline exercise identifies the drop, the reason for it can only guessed at without further inquiry. One factor behind the drop was that the introduction of the law created a period of uncertainty for some researchers about how the division of labor would change between researcher and institution. While the overall tendency of applications fell from the first half of the 6 year period to the second, the academic patents were *more stable*.

Table 3. Annual breakdown of unified patent applications[a] by response category

Response category	1998	1999	2000	2001	2002	2003	Total
Confirmed	112	143	159	147	148	119	828
Negative	24	24	19	22	17	17	123
Unresolved	21	32	47	36	44	46	226
Others	1162	1164	1195	1092	1019	968	6604
Confirmed %	8.5	10.5	11.2	11.3	12.1	10.3	10.6
Total numbers	1319	1363	1420	1297	1228	1150	7781

Source: Norwegian Patent Office-Inventor (Nifu Step), Norwegian Researcher Registry (Nifu Step).

[a] At least one Pro researcher contributing.

There were 414 patents with at least one PSR researcher both in 1998–2000 and in 2001–2003, while the number of other patents (including unresolved, negative and others) fell 11.6% from 3688 to 3261 from the end of the 1990s to the beginning of the 21st century. Academic patenting peaked as a proportion of total Norwegian patents within this period in 2002. Note that the period covers an economic downturn (2001). This downturn principally affected private sector patenting, particularly in the area of information technology. The IT-bubble affect is visible in Figure 1 which illustrates the year on year development of confirmed PSR patents by technological field. In 2003, academic patenting fell most significantly in the fields of process engineering and instruments.

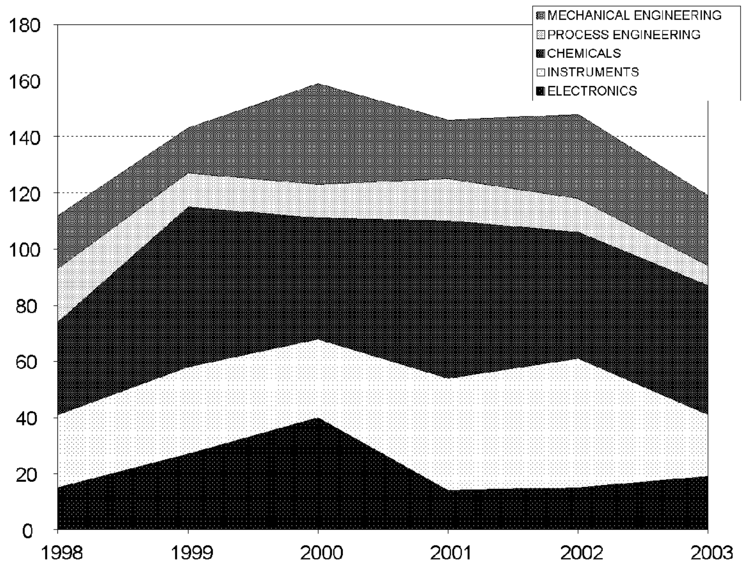

Figure 1. Annual trend of academic patents[a] by technological area (N = 828)
Source: Norwegian Patent Office-Inventor (Nifu Step), Norwegian Researcher Registry (Nifu Step)
[a] At least one PRO researcher contributing. The electronics area includes 64 applications which might not be attributable to the academic researcher who responded

Assignees: The new law grants title to the university or college who employs the researcher. This change of title will tend to change who applies for academic patents, so it is important to get an idea of the profile of applicants in the years leading up to the legislative change. Figure 2 breaks down the patent-applications with at least one confirmed academic inventor for the 1998–2003 period according to the primary assignee type.

This breakdown indicates that the conception of 'professor privilege' patents as predominantly single-inventor patents held by the researcher himself tends to be inaccurate in most sectors. Individual PSR inventor patents are in fact relatively limited. The exception here is Electronics, which includes a single applicant with 64 applications in the area of IT. As indicated above, it remains uncertain that the researcher is behind these Norwegian patents. In general the roles of two types of assignees are important. The first are private enterprise assignees which tend to play a significant role in academic patenting. Figure 2 demonstrates that this role is proportionally greatest in the case of Chemicals and Pharmaceuticals. It also constitutes nearly half of the Mechanical Engineering patents.

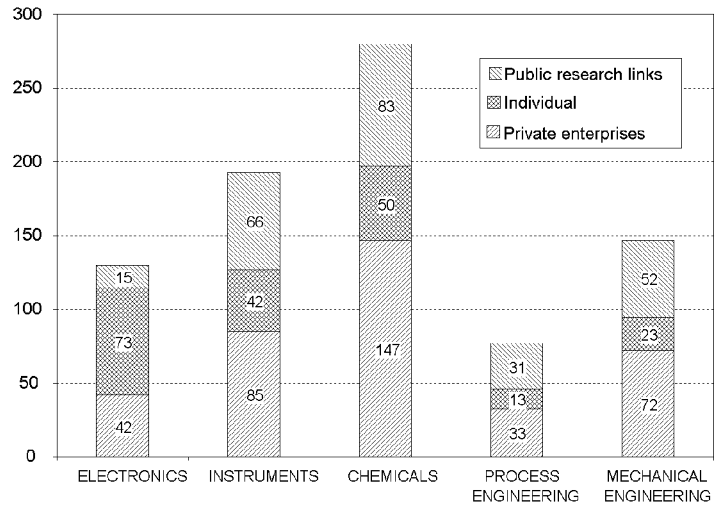

Figure 2. Type of primary assignees applying for patents with at least one academic inventor (N = 828)[a]
[a] One PRO patent does not link to a technological area. 63 of the electronic patents assigned to individuals involve one researcher and are uncertain. See elsewhere for discussion

The other significant assignee type is what we call 'public research links'. These include research institutes themselves (e.g. SINTEF), spin-off companies with clear affiliation to the public research sector (see above for a discussion), as well as technology transfer offices with explicit links to public research organizations. A small number of science parks are also listed as assignees. 'Public research links' are especially important assignees for Instrument and Chemical and Pharmaceutical inventions. It is expected that the profile of assignees will change following the new legislation. The important question will be what these changes will be and how they will affect the use of patents as a vehicle to disseminate academic research.

Grants: The above analysis has primarily focused on different dimensions of patent applications linked to public research organization researchers. An application in itself does not necessary indicate that the invention is patentable or, even so, if it is commercially interesting. In this sense, patent-grants tell us more about the relative merits of inventions while pointing to its success in being disseminated by patenting.

A granted patent provides a better indication of the aim of the new legislation. Grants however take time, typically three years. The final table in this explorative paper takes a preliminary look at what happens to the applications from PSR inventors. It looks at the status of PSR patent applications (as of the end of 2003) filed in 1998 as a proportion of all applications.

Table 4. Patents applied for in 1998 granted in the period, PRO application as percent of all. Status as of the end of 2003

Status	Electronics	Instruments	Chemicals	Process engineering	Mechanical engineering	**Total**[a]
Grant	10.5	18.2	22.7	18.9	5.2	**11.3**
Nongrant Withdrawal	8.4	14.0	28.1	4.2	1.7	**6.4**
Pending	0.0	36.4	45.5	0.0	0.0	**15.8**
Total %	8.9	17.1	27.7	9.6	2.8	**8.5**
Total	**169**	**152**	**119**	**198**	**678**	**1319**

[a] 19 applications of the total without affiliation (one is PRO, withdrawn).

In 1998 112 patents were applied for that involved at least one public research organization inventor. That accounts for 8.5% of the total 1319 Norwegian applications that year, which was the lowest level in the period. A significantly higher proportion of PSR patents were granted by the end of 2003 than the rest of the 1998 cohort. Whereas 35% of the cohort applications were granted, 46% – or 52 PSR patents – had been granted. The ration of grants to application was highest among PSR patents in the cases of Process Engineering and Mechanical Engineering.

Conclusions

This paper has addressed the fundamental difficulty of empirically assessing changing policy aims in the area of academic patenting. It has presented results from a project designed to provide necessary empirical basis on which to analyze changes in extent and focus of academic patents. The purpose has been in short to describe the project’s empirical approach and results, while also providing insight into the changes in Norwegian policy on this front and their context.

The paper presented a novel three-stage approach where the first stage links registry-data to identify public sector researcher involvement in patents; the second stage employs a survey which in part is used to verify the accuracy of the link; while the third combines the results from the survey with the registry-data to decide any cases left unresolved after the second stage. We argue that the use of an ‘affiliation network approach' (BALCONI et al., 2004) in the third stage is an effective way to resolve such cases. Overall, it is argued that the approach provides an accurate baseline for evaluating the effect of legislative changes in Norway which removed the "professor's privilege" and gave the higher education institutions formal responsibility for commercializing research results whenever possible.

The preliminary results of this approach are reported here. The paper demonstrates that more than 10% of all Norwegian patents involve public research organization inventors (or 12 percent of the times Norwegian inventors were involved in patent applications during the period). The majority of the PSR patents were linked with university and colleges. Academy patents made up nearly 5 percent of the fractional count of Norwegian patents (or 6.8% of the frequency). The contribution of university and college researchers was especially high in Chemical and Pharmaceutical patenting, accounting for nearly 18% (fractional count). This result confirms the conjecture (SCHMOCH, 2004) that PRS inventors play a major role in certain science-based technology areas. The baseline also indicates that PSR patents enjoy a high grant-rate relative to other domestic patents. 46% of the PSR patents applied for in 1998 were subsequently granted, as opposed to 34% for the population otherwise.

The proportion of public research organizations patents increased over the period 1998 to 2002, when 12 percent involved at least one PSR researcher. The baseline uncovers the interesting fact that in the year the new legislation went into force, 2003, to improve academic patenting, the level actually fell back to 10%. While the baseline itself cannot explain why the level fell, our conjecture is that the earlier than expected implementation of the legislation and the lack of established practice at the universities led to uncertainty among researchers. In this situation researchers preferred to postpone applications.

These results demonstrate some of key dimensions of the baseline of PSR patenting we constructed. Future iterations are envisioned, whereby this exercise is repeated periodically (every three years) together with the accompanying survey. This design will allow comparisons over time – and potentially, across countries – and should become instrumental to informing the future development of this important innovation policy area.

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