



HAL
open science

Traditional versus heterodox motives for academic patenting: evidence from the netherlands

Isabel Maria Bodas Freitas, Alessandro Nuvolari

► **To cite this version:**

Isabel Maria Bodas Freitas, Alessandro Nuvolari. Traditional versus heterodox motives for academic patenting: evidence from the netherlands. *Industry and Innovation*, 2012, 19 (8), pp.671-695. 10.1080/13662716.2012.739775 . hal-01487509

HAL Id: hal-01487509

<http://hal.grenoble-em.com/hal-01487509>

Submitted on 12 Mar 2017

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

CITE AS: “Bodas Freitas, I.M. and Nuvolari, A. (2012). Traditional versus Heterodox Motives of academic patenting: Evidence from the Netherlands. *Industry and Innovation*, 19(8), 671-695.”

TRADITIONAL VERSUS HETERODOX MOTIVES FOR ACADEMIC PATENTING: EVIDENCE FROM THE NETHERLANDS

ISABEL MARIA BODAS FREITAS

AND

ALESSANDRO NUVOLARI

ABSTRACT

This paper examines what motivates university researchers to patent the results of collaborative research with business firms. We provide evidence of the existence of a motivational academic patenting space comprised of: i) an industry-driven domain related to traditional-market motives (protection of inventions that will be commercialized); ii) a university-driven domain driven by various ('heterodox') motives related mostly to signalling specific research competences; iii) a 'hybrid' publicly-driven domain related to projects aligned to the research agendas of public sponsors. These three types of motivations reflect the connections between academic patenting and different types of innovation, and the roles of industry partners in proposing, financing and performing specific research projects. We use data from 16 in depth case studies of innovations developed by Dutch universities to provide preliminary empirical evidence of this typology of motivational spaces for patenting university knowledge.

Keywords: Patents, Motivations, Collaborations, University-industry interaction, Signalling

JEL codes: O34, O31, O38

1. Introduction

The increasing number of studies of academic patenting reflects a growing recognition of the critical role of universities for economic development, and the fact that the financing of university research relies heavily on the commercialization of research results.¹ The 1980s' US Bayh-Dole Act set new rules for the ownership of university research results and marked the emergence of a new context for academic patenting. Revisions to the regulation of intellectual property rights (IPR) on university research results are taking place in many other OECD countries. There is a general trend towards reinforcement of the incentives for university patenting, with the aim of facilitating knowledge transfer (see OECD, 2003, for an influential report that advocated policy changes).

Patents are a form of exclusionary rights granting temporary monopoly on the commercial exploitation of inventions. The traditional motivation for a patent application is the intention to appropriate some economic return from an invention, either through its direct commercializing or by licensing it to a third party. However, some scholars have suggested that other benefits, such as increasing bargaining power in technology agreements, signalling specific research capabilities, gaining access to research networks or enhancing reputation, may be influencing firms' decisions to patent (Hall and Ziedonis, 2001; Bureth et al., 2005; Penin 2005; Fontana et al. 2006).

These various reasons may apply also to academic patenting and it is useful also to make a distinction between traditional and 'heterodox' motivations in these cases (MacLeod, 1988). Traditional motivations are related to the expectation of appropriating some economic return from the legal protection of an invention provided by a patent. 'Heterodox' motivations include exploitation of a patent for purposes not directly linked to the protection of an invention: for example, to enhance reputation, signal competences, etc.²

Most policy discussion on academic patenting so far, revolves around the effects of patent protection, and tends to ignore the specific motivations underlying the academic researcher's decision to patent. If academic researchers patent for other reasons than protecting the economic

¹ In line with previous studies, in this paper, we use the term 'university patenting' to refer to university-owned patents, and academic patenting to indicate the broader set of both university-owned and university-invented patents (Lissoni et al., 2008).

² The distinction between traditional and heterodox motivations for patenting was introduced by MacLeod (1988) in her historical study of the English patent system. MacLeod noted that many patents granted in the period 1660-1800 were aimed at being used as advertising devices or, in the case of amateur, 'gentlemen' inventors, for public recognition of their scientific and technological efforts, rather than for the direct economic exploitation of a specific invention (MacLeod, 1988, pp. 75-96).

returns from their inventions then universities patenting policies may be misguided and need to be realigned (Metcalf, 1995).

Academic patenting seem to result from the analysis of the direct financial benefits generated by the patent as well as the indirect benefits such as effect on the individual researcher's scientific reputation or bargaining power inside the university (Owen-Smith and Powell, 2001; Baldini et al., 2007; Penin, 2010; D'Este and Perkman, 2011). Göktepe-Hulten and Maghagaonkar (2010) examine the importance of university researchers' reputational vs. pecuniary motivations to explain patenting and disclosure behaviour, and find that heterodox motivations are only important to explaining patenting by university researchers with no experience of collaboration with industry. However, we do not know whether or not different patenting motivations are associated with the specificities of the innovative process, in particular, the organizational format and technological objectives. The characteristics of the innovation development process may influence the patenting decision, especially under collaborative arrangements between industry and university (Colyvas et al., 2002; Aghion and Tirole, 1994; Verspagen, 2006).

This study constitutes a preliminary exploration of academic patenting motivations in the context of collaborative projects with different organizational and technological characteristics. We explore how traditional and heterodox patenting motives relate to different types of innovation ('embryonic' versus 'ready-to-use'), different forms of financing and organizing research, and different patent ownership. On the basis of 16 case studies of university-industry collaborative projects in the Netherlands we propose and provide evidence of the existence of a three-domain motivational space for academic patenting comprising: i) an industry-driven domain related to traditional-market motives (protection of inventions that will be commercialized); ii) a university-driven domain related to heterodox motives (mostly related to the signalling of specific research competences); and iii) a 'hybrid' publicly-driven domain that includes projects aligned to the research agendas of public research sponsors. This three-domain motivational space reflects the different connections between incentives to patent and types of innovation, and the role of industry partners in proposing, financing and performing specific research projects.

The paper is organized as follows. Section 2 reviews the motives for academic patenting; Section 3 proposes the conceptual framework for university patenting; and Section 4 presents the data used. Section 5 discusses the characteristics of the projects in each of the three motivational spaces, and the co-occurrence of patenting motivations, innovation characteristics and involvement of an industry partner. Section 6 concludes with some implications for policy.

2. Motives for patenting

A patent is a legal tool that grants an inventor the temporary exclusive rights to produce, use or market a specific invention. Traditionally, it was believed that in the absence of patent protection, competitors would immediately copy the invention, at almost no cost, giving the original inventor little hope of recouping the investment in the inventive activity (Verspagen, 2006). Empirical research on patenting motives, however, reveals a more complex picture. First, in most industries (notable exceptions being chemicals and pharmaceuticals) first-mover advantages and secrecy are considered to be far more effective methods than patents for protecting innovations (Cohen et al., 2000). Second, patents are used frequently by firms for other strategic objectives than protection of innovation. For example, the Carnegie-Mellon survey revealed that alongside the usual motives of preventing copying and generating revenue through licensing, patents are used to block rival patents, to negotiate with other companies to prevent infringement suits, to enhance reputation and to measure the performance of R&D departments (Cohen et al., 2000). Other studies show that patents can combine the traditional role of protection and exclusion with the heterodox role of a negotiation and cooperation instrument (Hall and Ziedonis, 2001; Bureth et al., 2005; Bureth and Penin 2007). In other words, patents simultaneously act to promote collaboration and protection. Bureth and Penin (2007) argue that patents can be understood as architectural elements of complex modular products because they protect against competition (within each module, they act as tools of exclusion and protection) and foster cooperation (across modules). This heterodox role of patents is more frequent in the area of life sciences (Bureth et al., 2005).

In the case of academic patents, the situation is more complex. As Verspagen (2006) points out, university research can be regarded as a prime example of a system of patronage, in which the development of new knowledge is supported directly by public funding. Therefore, university research is knowledge created by an incentive system, which, from a historical point of view, has emerged as an *alternative to the patent system*. In this perspective, the rationale underlying current policy measures that encourage the patenting of university research findings appears to be ambiguous because these procedures create incentives for investment in the production of new knowledge by actors whose research efforts are supported by public funds (Jensen et al, 2003; Verspagen 2006). Not surprisingly, much of the research on academic patenting focuses on the effects of the co-existence of these two incentive systems – public funding and patents - on the behaviour of academic researchers. Several studies examine issues such as possible delays in the publication of research results, diversion of effort from basic, fundamental research to more ‘applied’ work, etc. (Geuna and Nesta, 2006; Manjarrés-Henríquez et al., 2008; Welsh et al., 2008; Penin, 2010). Concern about the possible detrimental effects of

patenting university research results came to a head between 1910 and 1939 when some US universities began to take patents on some of their discoveries (see Metlay, 2006 for an interesting study of these early discussion on the rationale for university patenting).

Empirical research on academic patents tends to focus on traditional reasons for patenting (e.g. Colyvas et al., 2002; Jensen and Thursby, 2004). However, as already mentioned, research on corporate patenting reveals that patenting can have many different motives. This leads to questions about whether the patterns of motivations are similar for university patenting and whether patenting occurs for other reasons than protection. Such an investigation is important to assess the potential effects of recent public policy measures designed to encourage university patenting.

Few studies examine heterodox and traditional motivations for academic patenting. In the US, university patenting and disclosure behaviours seem to be affected by the expectation of personal pecuniary rewards (e.g. Owen-Smith and Powell, 2001; Friedman and Silberman, 2003). Studies using European data suggest that heterodox patenting motives, such as access to research funds and resources, and reputation are more important (e.g. Baldini et al., 2007). In particular, Göktepe-Hulten and Maghagaonkar (2010), using survey data, examine the importance of reputational and pecuniary reasons for patenting and disclosure behaviours among university researchers - with and without industry-collaborative experience. Their results suggest that heterodox motivations are only important for explaining patenting by university researchers with no experience of collaboration with industry, and that pecuniary motivations are negatively associated with disclosure and patenting by university researchers with industry cooperative experience. Given the nature of survey data, Göktepe-Hulten and Maghagaonkar (2010) are unable to identify how these motivations are associated with different types of innovative processes, and do not take account of the organizational form or technological objective of collaborative projects with industry.

However, the characteristics of the invention and its development process seem to influence the motivations to patent, especially under collaborative arrangements between industry and university (Colyvas et al., 2002; Aghion and Tirole, 2004; Verspagen, 2006). Aghion and Tirole (1994) argue that the allocation of IPR in university-industry collaborations is related to both the nature of the innovation and the characteristics of the research team.

The present study provides a preliminary exploration of academic patenting motivations, and especially heterodox and traditional incentives, in projects with different organizational and technological characteristics, conducted in collaboration with industry. Section 3 proposes an

interpretative framework for understanding the incentives for universities and academic researchers to apply for patents on research findings.

3. Motivational spaces for patenting university research results

We start by considering that the motivations for university patenting are an outcome of the context in which the new knowledge is generated. In other words, patenting of innovations developed in collaboration with industry and patenting of innovations developed autonomously by academic researchers may have different intrinsic motivations. The reasons for patenting may vary across different phases of development of an innovation (i.e. whether the innovation is at an ‘embryonic’ or ‘ready-to-use’ stage). Also, university or industry ownership of the IPR of an innovation seems to depend on the context of its development and the level of development and applicability of the knowledge (Colyvas et al., 2002; Metlay, 2006; Verspagen, 2006).

Embryonic, proof-of-concept as opposed to ready-to-use innovation is more likely to be protected by a patent for heterodox reasons such as signalling and attracting partners that could provide financial support for further development and refinement of the invention (Colyvas et al., 2002; Bureth and Penin, 2007). Innovations that replace existing technologies and open up new market opportunities are more likely to be patented for heterodox motivations (Metlay, 2006). In both cases, although part of the reason for patenting may be traditional protection, it is important for the inventor to attract new research partners and resources to allow further development of the innovation (Geroski, 2000; Metcalfe, 2005).

Embryonic proof-of-concept and ready-to-use innovations tend to be developed in different organizational environments, and have different objectives and arrangements for eventual ownership. Proof-of-concept inventions developed by universities are typically generated in ‘curiosity-driven’ type research contexts, supported by public funds and, for these reasons, will be less suitable for immediate industrial application. University-owned patents tend to refer more often to embryonic innovation based on public funds than private patents (Colyvas et al., 2002; Azagra-Caro et al., 2006).

Innovations developed in contexts of limited interactions with industrial firms, or autonomously by academic teams, are more likely to be patented for heterodox motivations than innovations developed in direct cooperation with firms (Göktepe-Hulten and Mahagaonkar, 2010). In the former case, patenting provides a way for academic researchers to signal to public research sponsors, the quality and potential for industrial application, of their ongoing research and to attract private funds and partners for future innovation development projects (Geuna and Nesta, 2006; Czarnitzki et al., 2011). In the latter case, heterodox motivations for patenting may be less

important in contexts of strong interaction with industrial firms, especially if these firms participate actively in the design and performance of the research collaboration. Hence, university researchers with experience of collaboration and interest of continued cooperation with industry may mimicking the traditional market-led patenting motivations of their industrial partners who are more likely to expect and understand the market potential of an innovation (Slaughter et al., 2002).

Based on these considerations, we suggest a typology of university-industry interaction comprising three broad domains of motivations for academic patenting based on the type of innovation and the organizational and financial contexts of the research project: *Industry-driven*, *University-driven* and *Publicly-driven* (see Figure 1) Figure 1 considers a research project as spanning three dimensions: i) the degree of involvement of industrial partners; ii) nature of the innovation; iii) type of motivations for the decision to patent. This leads to the identification of three types of research projects: *industry-driven* where patenting is mainly for traditional motives; *university-driven* where patenting is likely to be driven by heterodox motives; and *publicly-driven* ‘hybrid’ type projects where patenting combines traditional and heterodox motives.

[Figure 1 about here]

[Figure 2 about here]

Figure 2 depicts the characteristics of each motivational space for university patenting behaviour. The *industry-driven* refers to collaborative research and development (R&D) projects where a firm that is familiar with the research competencies of the university based on previous collaborations or professional contacts, proposes a collaborative project or asks for help in resolving a technological problem. These projects are often high on the firm’s research agenda and its in-house research groups are likely to contribute directly. Depending on the type of research, the university researchers may perform their research at the firm’s facilities in order to access specific equipment and facilities. The firm tends to finance most of the research costs. These types of projects may be aimed at improvements to existing technological applications, prototypes, or product commercialization. Patents are typically aimed at protection and, in most cases, are owned by the firm. University researchers working in close collaboration with industry researchers tend to reproduce the patenting motivations of their industry partner. Continuation of the project and direction of the research may depend on the firm’s interest in supporting it by providing access to equipment, testing facilities and/or funds, and the possibilities for the firm to appropriate some benefits from the collaboration.

University-driven research tends to be conducted in an academic or government institute and be mostly ‘curiosity driven’ although it may be the result of some contract research and may lead to a by-product innovation. Innovation is usually developed in research projects performed almost exclusively by university researchers; if a firm is involved this usually consists of provision of material, equipment or technical feedback. *University-driven* projects are usually financed by public research grants or exploit university resources such as masters and research students. Patenting of research outcomes (usually proofs-of-concept or substitute for existing technologies), tends to be driven by heterodox motives, including signalling of research competences, access to research funds, and opportunities to continue the research agenda.

Publicly-driven research refers to projects related to technical proofs-of-concept and prototypes aligned to the research agendas of the public research sponsors. These projects rely on a mix of private and public funding, and involve different forms of organization of research activities between the university and the firm. They tend to be related to innovations to substitute for existing technologies. Patenting the results of these projects is led by traditional as well as heterodox motives.

4. Data and Methodology

The empirical evidence used in this paper relates to academic patenting in the Netherlands. *Prima facie*, the Dutch case is particularly interesting. The Netherlands has the highest shares of business-owned patents based on university knowledge and business patents with university inventors (Verspagen, 2006). Recent estimates suggest that 4.3% of Dutch patenting with the European Patent Office (EPO) relates to academic inventors (similar to the levels in other European countries such as France and Italy) and that on 1% of Dutch EPO patents the assignee is a Dutch university (the corresponding percentages for France and Italy are lower) (Baselli and Pellicciari, 2007; Lissoni et al., 2008).

The Dutch university system historically has enjoyed a high level of autonomy from central government. Funding of Dutch universities comes from three main streams. The first is public funding which is allocated according to numbers of students and fields of study. The second stream is represented by funding for research, allocated through competitive grants awarded by the research councils (the most important is the NWO, Nederlandse Organisatie voor Wetenschappelijk Onderzoek). The third funding source is contract research involving both business firms and public partners. The share of this third stream is about 30% at the national level (VSNU, 2012).

Technology Transfer Offices (TTOs) began to be established in Dutch universities during the 1980s and early 1990s. In the European context, Dutch TTOs provide effective IPR consulting services (OECD, 2003; Verspagen, 2004). The Dutch university system does not acknowledge the so-called ‘professor’s privilege’, which means that Dutch universities and public research organizations can assume ownership of the inventions made by their researchers. The decision to patent, therefore, is not confined to individual researchers, but is the outcome of discussion or negotiation with the TTO. Although the legislation has not changed, the Dutch government has been encouraging more patenting of the results of academic research (Minister of Economic Affairs, 2003; Verspagen, 2004). This can be seen as part of a broader shift in Dutch innovation policy, which increasingly is trying to link public research funding to industrial applications that provide direct contributions to social welfare.

We collected novel project/collaboration level data from 30 case studies of university-industry collaboration, to investigate the dynamics of the organizational and technological structure of the cooperative projects. The unit of analysis is the piece of knowledge developed or co-developed at the university and transferred to the firm, regardless of whether it is used or commercialized.³ We focused on completed projects where the knowledge developed was transferred to the firm, independently of whether the firm has recognised its value or decided to use it. By focusing only on completed projects we were able to collect data covering both project origins and achieved outcomes. However, it may be that this choice of completed collaborative projects biases the sample towards successful cases, although we found a mix of performance.⁴ Also, we focus on patenting motivations rather than performance *per se*.

We used several strategies to identify our cases, including interviews with the chairs of research departments in the faculties of mechanical engineering, biotechnology, chemistry, applied physics and electrical engineering in two technical universities in the Netherlands (Eindhoven and Delft); library searches for PhD theses completed in the previous five years; records of research grants awarded by national research councils; interviews with directors of university TTOs; and identification of professors with large numbers of industrial patents.

³ Among the 30 cases, we found three levels of knowledge transfer: knowledge transferred but not valued or exploited by the firm; knowledge that was absorbed by the firm which regarded it as valuable but did not exploit it further; and knowledge that was exploited in further research, product development, process improvements or commercialization of new products.

⁴ In 2 of the 30 cases, the collaborative project did not achieve the scientific or technological objectives defined at the start of the project; in 4 cases the outcomes were beyond what was expected; in 17 cases, projects led to commercialization efforts or plans for commercialization of new products. The universities evaluated 26 projects as completely positive; the firms were more critical and reported complete satisfaction with outcomes in only 21 cases.

Since this work is exploratory we are interested in variety in our sample of cases. The 30 cases demonstrate variety in forms of funding, scientific disciplines, and origin and development of inventions (university-driven research; firms proposing project ideas to the university; results of on-going collaboration).

To enable codification and statistical comparison of the cases, we developed a standardized protocol for collecting data from university researchers and industry researchers and managers participating in the specific projects. This protocol included over 200 questions focusing on the processes of knowledge development and transfer between universities and firms, which includes (Bozeman, 2000; Bercovitz and Feldman, 2006): i) characteristics of the innovation; ii) identification of project origins; iii) design and performance of the R&D project; iv) degree and forms of knowledge transfer between university and firm; v) impact of the knowledge transfer process; vi) main characteristics of university researchers and participating firms.⁵ Collection of data in each case involved between two and five interviews with the university and industry partners.

We identified 16 cases from the original 30 case studies that involved academic patent applications, that is, applications based on a decision to patent by the university researcher. Our sample of 16 cases includes 4 cases related mainly to Mechanical Engineering, 3 in Biology and Medicine, 3 in Applied Physics, 3 in Electrical Engineering, 2 in Chemistry and Chemical Engineering, and 1 in Bio-mechanics. In nine cases, the idea for a collaborative project came from the university researchers; three of these were former industry researchers, and two were part-time professors. Five cases were mainly proposed by firms; the others were continuations of previous or on-going collaborative research. In relation to funding, two cases were supported by public subsidies, five were fully financed by the firms, and the remaining nine were funded by a mix of public and private sources.⁶

Table 1 provides information on the technology, disciplinary affiliation, type of funding for development, relative size of research team in yearly full-time equivalents (FTE), project timing and timing of patent application and its ownership.

[Table 1 about here]

⁵ The protocol consists of mainly open questions and some yes/no questions.

⁶ 11 cases relate to the University of Eindhoven, 3 to the University of Leiden, and 2 to Delft University.

In relation to timing of patent applications, in 10 cases, projects built on previous patents; 6 were patents on university knowledge (2 owned by the firm). In 15 cases, patents were awarded during or towards the end of the project; in only two cases was the patent university owned.

In four cases, the project led to the creation of a spin off firm, one of which was a start-up. In three cases, the spin off was the form used to implement the research project because it facilitated access to research sponsorship and collaborative agreements.

The categorization of innovations into embryonic or ready-to-use innovations is difficult because the meaning of these terms differs across disciplinary fields and industrial contexts. To address this, we create two objective dichotomous variables that can be used as proxies: 'substitute versus complement to existing technologies', and 'degree of technology development' (Geroski, 2000; Metcalfe, 2005). The variable 'substitute versus complement to existing technologies' defined in terms of knowledge application rather than knowledge characteristics, considers whether the existing innovation complements or substitutes the existing technology (Metcalfe, 2005). The variable 'degree of technology development', reflects the different development phases leading to new technology and knowledge at the end of the research project, and considers whether the project resulted in proof-of-concept rather than a developed crafted technology or industrial application. These variables are based on information reported by interviewees on the characteristics of the innovation, complemented in some cases by secondary sources.

Innovations that are complementary to existing technologies represent less complex ways to improve technology efficiency and market performance. Innovations that represent substitutes for existing technologies may involve deeper organizational changes to establish a market (Geroski, 2000; Metcalfe, 2005). Therefore, the motivations for patenting these two types of innovations can be expected to be different (see Section 3). This classification allows us to control for disciplinary differences in the innovation development time frame. Hence, these dichotomous variables capture the degree of substitution/complementarity with existing technologies and degree of technology development, which allows comparison across disciplinary fields and industrial contexts.

Among the 16 cases, 12 focus on knowledge related to technologies that are substitutes for existing ones. Eight cases led mainly to development of proofs-of-concept of new technologies and eight cases resulted in crafted prototypes and industrial applications.

We use data collected from both university and industry partners to characterize the innovation development process, the innovation, and the forms of financing and organizing the research

project. We use information provided by university researchers participating in the 16 cases to reconstruct their motivations for applying for patents on pieces of new knowledge generated during the project. We coded the motivations reported by university researchers into 7 different motivations, traditional (3) and heterodox (4). In this study we examine motivations in the context of collaboration, which involves teams of researchers. Consequently, we include (all) the motivations reported by the university researchers involved in the innovation development project rather focusing on the motivations of individuals, departments or universities.

5. Motivations for academic patenting

5.1 Motivations for patenting, types of innovation, research funding and patent ownership

We codified the motivations reported by university researchers into traditional market-related and heterodox-signalling motivations. The traditional-market patenting motivations identified are: ‘Securing the benefits from future product development’, ‘Guaranteed ownership of IPR on new products’ and ‘Return on R&D investment from sale of innovation’. Securing the benefits from future product development refers mainly a pre-emptive claim by the patent owner on the rights over future developments based on innovation. Guaranteed ownership of IPR on new products’ allows the patent owner to commercialize the product without others being able to claim right or inappropriate use of their IPR. Selling the information to obtain a return on R&D investment is directed mainly to obtaining a (partial) return on earlier investment in research when the firm is no longer interested in directly applying the innovation.

The heterodox-signalling motivations identified are: ‘Publication of valuable research results’, ‘Signalling to potential (industry) research partners’, ‘Attracting venture capital’, ‘Attracting research funds’. The first refers to the diffusion of valuable research results and building scientific and industrial reputation. Signalling to potential partners is aimed at attracting future collaboration partners demonstrating technical capability and assuring exclusivity of research results. Attracting research funds is aimed at attracting (mainly public) funds for new research projects along similar lines. Attracting venture capital is mainly to fund the cash flow of spin offs in addition to R&D.

Table 2 provides information on the frequency of the motivations identified by researchers involved in the case projects, and on the degree of complementarity/substitution among motivations. In all cases, one of the motivations for patenting was in the traditional category. In ten cases, at least one motivation was heterodox. Securing the benefits from future product development and Guaranteed ownership of IPR on new products’ were cited in 11 cases.

Signalling to research partners and Attracting R&D sponsorships were the motivation in eight cases; and Publication of valuable research was the motivation in seven cases.

[Table 2 about here]

Heterodox and traditional patenting motivations, therefore, are not mutually exclusive, which is in line with research on motivations for industrial patenting (Bureth et al., 2005; Bureth and Penin, 2007). Only the traditional motivation of Guaranteed ownership of IPR on new products seems to be a substitute for heterodox motivations (significant and negative correlation coefficient). It is somewhat surprising that traditional motives (compared to heterodox motives) do not seem to complement each other (no significant correlations were found).

Table 3 provides information on frequency and linear association between the motivations for patenting and the characteristics of innovation in relation to the degree of technological development and substitution among existing technologies.

[Insert Table 3 about here]

Eight projects focused on development of proofs-of-concept, and patenting in all these cases has heterodox motives. Eleven cases were substitutes for rather than complements to existing technologies; heterodox motivations were reported in nine cases. Heterodox motivations for patenting seem more likely to be related to proofs-of-concept and innovations that are substitutes for existing technologies.⁷ This suggests that the more embryonic the knowledge produced by the project the more likely the motivations for patenting will be heterodox.

The traditional motive of securing the benefits from future product development is reported in seven cases focusing on development of proof-of-concept, and nine projects related to the development of substitutes for existing technologies. Hence, there does not seem to be a link between traditional market-related motivations for patenting, and the characteristics of the innovation. Obtaining a return on R&D investment seems to be related mainly to innovations complementing rather than substituting for existing technologies. An innovation that is considered to be readily marketable is one for which there is an already existing supply and demand market, that is, an innovation that complements an existing technology (Geroski, 2000; Metcalfe, 2005).

⁷ Heterodox motives for patenting seem particularly frequent in research projects in Biology and Medicine.

Table 4 provides information on the frequency and association between the motivations for patenting and the role of the project's industrial partners.

[Table 4 about here]

In 11 cases, the industry partner participated in the design of the research. In 10 of these cases, the motivations for patenting were traditional, and 7 there were heterodox motivations. In research projects where the industry partner actively participated in the research activity (7 cases), traditional patenting motivations are slightly more frequent. In these cases the traditional patenting motivation was guaranteeing IPR on new products. In only three of these seven cases were heterodox-signalling motives reported as reasons for patenting. Since industry partners invest resources and time in collaborative projects, and interact with the university researchers, motivations related to the appropriation of market value, which tend to be more aligned to achieving immediate industrial applications, are more frequent. In five cases, the industry partner financed a large part of the research activity; in none of these cases was access to venture capital identified as a motivation for patenting, and heterodox motivations were reported in only two cases. In four of these five cases, the motives were traditional. Thus, the evidence suggests that the higher the involvement of the industry partner in the research project the less likely that the motives for patenting will be heterodox.

Finally, we examined the frequency and linear association between patenting motivations and the existence of previous patents including all previous patents, previous patents based only on university developed knowledge, and previous university-owned patents. The impulse to patent seems not to depend on the existence of a previous patent (i.e. of a patent granted prior to the emergence of the new research results). Only the motivation of securing the benefits from future product development was found to be slightly more frequent in collaborative research to develop previously existing patents, independent of the type of their patent ownership.

We find a weak association between patenting motivations and ownership of patents issued during or towards the end of a research project. In the case of research results belonging to the university (leading to a university-owned patent), patenting seems slightly more likely to be motivated by the heterodox objectives of publishing valuable research results and building scientific and industrial reputation; traditional-market patenting motivations seem less important in the case of university patenting. The motivations for academic patenting, therefore, may

depend on whether the university retains (or not) the property rights to the results of a collaborative research project.⁸

5.2 Typology of university-industry collaborative projects and motivations for academic patenting

To explore the applicability of the taxonomy of motivational spaces to patenting of university knowledge, we split the cases into three groups - cases where no heterodox motivations were found, cases with at least three heterodox motivations, and cases with one or two heterodox motives - and analysed similarities and differences within and across groups.

First, we analyse the characteristics of the six cases where patenting was not led by heterodox motives. Five of the projects were proposed to the university by firms and fitted with the firms' research agendas. None of the projects resulted only in proof-of-concept; all resulted in improvements and refinements to existing technologies. In three cases, the projects led to commercialization of a new product. In two cases, the innovation was a substitute for an existing technology. Two cases were in the area of Mechanical Engineering, two were in Electrical Engineering and two were in Applied Physics.

Four of the six cases were financed mainly by the firms, which participated directly in the research. In three cases university researchers joined the firms' research teams. A fifth case, was financed mainly by public research sponsors, was conducted at the university, and was initiated and led by a part-time professor who was employed by the industry firm. The sixth case was a university department that had been working on an industry related problem for over a decade before the methodology used to address the problem resulted in a spin off. When the product was developed and patented the university department closed down. This group of cases fits the industry-driven domain of motivations for patenting university developed knowledge. Strong involvement and the interest of university researchers in industry's activities seems to reproduce the market related patenting motivations traditionally applying to their industry counterparts.

The next six cases involve at least three heterodox motives for patenting. All relate to proof-of-concept outcomes that complement existing technologies. Five of the projects were financed by public sponsorship or university funds. These projects were developed mainly at the university. Industry partners were not directly involved in performing the research, although they provided material, equipment, testing facilities and feedback. Three cases were in the areas of Biology and Medicine, the remaining three respectively were in Chemistry, Mechanical Engineering and

⁸No significant relationship was found between patenting motivations and the type of patent (domestic/international) issued.

Electrical Engineering. This group of cases belongs to the university-driven domain the patenting motivations.

In the last four cases, patenting motives were both traditional and heterodox. Three refer to development of substitutes for existing technologies; two refer to proofs-of concept (one project was discontinued as soon as the firm obtained proof-of-concept knowledge). The projects were in the four disciplinary areas of: Mechanical Engineering, Medicine, Chemical Engineering and Applied Physics. This ‘intermediate’ group overlaps with the previous two groups. In one case, before engaging in the collaborative project, the firm had patented university knowledge, which, the university permitted to secure industry collaboration (the university also reported some of the firm’s pre-emptive traditional-market motives). In another case, a university-owned patent, patented for heterodox motivations, existed prior to the collaborative research project, which was aimed at developing knowledge related to the existing patent. The firm patented the emerging results while the collaborative project was still running. The motivations reported include the heterodox motives of attracting other industry research partners and accessing public funds, as well as some traditional-market reasons. The remaining two projects were financed mainly by public research funds and patenting was motivated by diffusion of research results and attracting more research funds.

This analytical and descriptive exercise of clustering cases according to the presence of heterodox motives for patenting provides some insights on the multivariate nature of the motivational spaces encompassing patenting decision. It discusses how and why research projects that differ according to the role of the industry partner in proposing and financing the project and participating in the research, tend to produce different types of innovations and result in different motivations for patenting. The empirical evidence supports the taxonomy of motivational spaces for patenting derived in Section 3.

5.3 Three typical cases

In this section, we summarize three projects that can be considered typical of the industry-driven, university-driven or public-driven domains according to the patenting motivations identified by the researchers involved in the projects.

Industry-driven collaborative project

The invention was an improved control system for complex manufacturing machines (e.g. wafer scanners). The invention process involved collaboration between the Department of Mechanical Engineering in a technical university and a leading Dutch manufacturer of integrated circuits.

The motivation for the project was the company's need to improve the efficiency of its wafer scanners. Aware of these technical concerns, the university project leader proposed the setting up an 'applied' PhD research project with the aim of designing more efficient control system software. Although the innovation project was formally proposed by the university partner, through previous contacts the company had expressed its need for the innovation. The PhD research project was initiated (the PhD researcher's salary was covered by the company) and proceeded smoothly. The research was developed based on interaction between the university and industry researchers; a large part of the PhD student's time was spent at the firm. The project led to the creation of working prototypes of software control systems, some of which were adopted by the industry partner. The knowledge generated by the project was protected by six patents, which were owned by the industry partner. This is a clear case of industry-driven innovation. The industrial partner has a technical problem; the university partner with the appropriate experience (perceived through previous contacts) is approached to provide a workable solution. For the university partner, resolution of this technical problem for the firm did not provide particular tensions or distractions from ongoing research (the PhD project was completed on time). The knowledge generated by the project was geared to solving a specific industry problem and the results were appropriated by the industry partner, who then applied the patent protection in a 'traditional' way. The industry partner controlled all dissemination of the knowledge (e.g. all publications related to the project were checked carefully by the firm's IPR department; findings were published with minor delays). The university partner was not frustrated by this level of checking and the slight delays because of experience of interacting with firms for research (supervisor) and strong interest in interacting with the business world (PhD student).

University-driven collaborative project

The innovation is inorganic crystalline phosphors for labelling macromolecules in biological systems. It represents a major improvement over other labelling methods such as radioactive labelling techniques. The potential application of this technology is medical diagnostics. The project originated with the university. The idea was the result of PhD research conducted in the Molecular Cellular Biology Department in the Medical Centre of a large Dutch university. As soon as the potential of the innovation became clear, the university department applied for a patent on the research results. This was not a 'ready-to-use' innovation and major development work was required for the technology to be applied within a diagnostic tool. After the patent was granted, research continued funded by NWO grants. It is likely that the patent played a role in the award of this funding to the department. At the same time, the department began to look for potential industrial partners that might be interested in developing the technology. After careful scanning, a suitable industrial partner was identified. It was a US company already

engaged in work on the use of crystalline phosphors unknowingly using technology that likely infringed the university patent. A cooperation agreement was drafted and the US company bought the patent rights. This is an example of the co-existence of traditional and heterodox patenting motives. The original patent was used by the university partner to signal specific research competencies and reputation. During the collaboration project, the patent rights were transferred to the industry partner which used them for traditional protection and commercializing of the innovation. In this second phase, as the invention was improved and developed by the university and the firm together, the industry partner applied for additional patents. Curiously, after a somewhat tortuous history and due to difficulties related to making the technology viable for practical application, the original patent reverted to the university department (the original cooperation contract included a clause about ‘abandonment’ of the patent), a year before it expired, since the firm had decided not to commercialize.⁹ The university continued to work on this project and was awarded a research grant from a US sponsor.

Publicly-driven collaborative project

The innovation is a flywheel for application in automobiles to support propulsion of the engine when rapid acceleration is needed. This device, which can be retro-fitted, has the potential to economize on fuel. The innovation was the outcome of a collaborative project involving the Department of Mechanical Engineering in a Dutch technical university and a Dutch manufacturer of transmission systems for automobiles. The partnership was supported by a government programme to support environmentally-friendly research projects – especially through university-industry partnerships. The project involved several PhD researchers whose assigned task was to deliver a ‘proof-of-concept’ of a flywheel system. The project led to four patent applications. One of the outcomes of the project was the creation of a spin-off company since the original company was not interested in diversifying and exploiting the innovation. A university spin-off, owned jointly by the firm and the researchers, was seen as the best way to commercialize the invention. Accordingly, patent rights were transferred to the spin-off company. The technology in question was not immediately applicable, but was developed beyond the embryonic stage. In this case there was a combination of traditional (secure market returns) and heterodox motivations (attract sponsoring and venture capital) for academic patenting.

⁹ In most of our cases, IPR agreements were not formally established before the collaborative project involving the university and the firm was initiated. IPR agreements applied mainly to projects in Biology. Projects funded by national research sponsors have to abide by the IPR rules set by the research sponsor.

6. Conclusions

This paper proposed an exploratory framework to examine the motives for academic patenting in different types of university-industry collaborative research projects. Consistent with the previous literature, we proposed three typologies related to the differences in types of innovation, organizational format of research projects and motivations for patenting. *Industry-driven collaborative* projects lead to patenting mainly for traditional-market related motives; *university driven* collaborative projects involve several heterodox motives, related to the need for researchers to find industrial partners for future knowledge development, to increase access to public R&D funding, or to support spin-off creation and growth (venture capital and public support). *Publicly driven* projects result in patenting for heterodox motives. This three-domain space reflects the different links between patenting motivations and types of innovation, and the role of industrial partners in proposing, financing and performing specific research projects. Our in-depth evidence on 16 cases of innovations developed or co-developed in Dutch universities supports this taxonomy.

Our evidence suggests that traditional motives for patenting apply to almost all patents, and that heterodox and traditional patenting motivations are not mutually exclusive. Heterodox motivations for patenting are more likely in the case of innovations that are ‘embryonic’/proof-of-concept or are radical substitutes for existing technologies. They are also more frequent if research is public financed, and performed mostly by the university leading to a university patent application. Our results suggest also that university researchers, with experience of industry collaboration or interest in future interactions with industry partners, are likely to reproduce traditional market-related motives for patenting.

The most important implication for policy-makers and TTO managers is that academic inventors may be motivated to apply for patents for heterodox reasons. These reasons have generally been ignored in the literature on university patenting, which is unfortunate because they have some implications for policy. Heterodox motivations for patenting, including signalling competences, attracting industrial partners and accessing research funds, may be regarded as positive by policy makers, since they are seen as demonstrating the university’s effort to diffuse the results of academic research and to engage in technology transfer. However, it should be remembered that all patents involve a reduction in social welfare via their effect on reducing competition. In some cases, these negative effects are exacerbated by the effect of a patent related to blocking subsequent technological developments (hold up problems). Innovation policy should limit patenting to only what is required to stimulate investment in the inventive activity.

Second, patents, especially university patents, represent only the commercial and codified aspects of innovation and effective knowledge transfer between university and industry, in most cases, requires articulation using more informal interaction, such as informal contacts, open communication, collaboration and consulting, than the simple licensing of a patent (Cohen et al., 2002; Bekkers and Bodas Freitas, 2008).

Third, our evidence suggests that researchers with longer experience and/or interest in interacting with industry firms tend to reproduce the latter's objectives and motivations. Hence, too much industry involvement in academic research may restrict communication among scientists because of the secrecy rules set by firms and their keenness to commercialize research results and to patent (Slaughter et al., 2002; Welsh et al., 2008). It may also undermine future pay-offs from academic research not only because of the incentive to focus less on basic curiosity-driven research, but also because it inverts the values of traditional academic freedom (Slaughter et al., 2002; Goldfarb, 2008).

Current incentives to patent research results such as those introduced by many European countries emulating US regulations and practices (see Mowery and Sampat, 2005, for an overview of these attempts to emulate the Bayh-Dole Act) may be exacerbating university budget constraints because they favour patenting at an early stage in the research. As some authors point out, patents are becoming a double-edged policy sword and the balance between their positive and negative effects (especially related to hold up problems that delay follow-up innovations) is becoming increasingly difficult to achieve (Bessen and Meurer, 2008).

The evidence in this paper points to the existence of heterodox motivations for academic patenting, but does not shed direct light on the relevance of the consequences of heterodox patenting motives. In light of the existing literature and the evidence in this paper, and until we have a more sophisticated understanding of the phenomenon of heterodox motivations for patenting, we would recommend a more cautious approach to academic patenting.

Our study has some limitations which point to avenues for future research. First the analysis uses unique project level data and, necessarily, relies on a small sample of observations. This limits the type of statistical analysis possible, and means our results are exploratory. Further research is needed on larger samples that exploit different methods of enquiry and analysis. In particular, it would be useful to establish the relative importance of our three 'ideal' types. Second, we focus on the motivations for academic patenting, under different collaborative arrangements, and in relation to completed projects. Academic patenting of research results with no industry involvement may fall into the university-driven motivation domain (Göktepe-Hulten and Mahagaonkar, 2010). However, university patenting leading to the creation of university

spin-offs by academics, with no industry involvement may also be the result of traditional-market related motivations. Similarly, academic patent applications in relation to collaborative research in projects cancelled before the patent is granted may be due to heterodox motivations. Further research is needed to address academic motivations in different contexts.

Third, we rely on case studies of university-industry collaboration in the Netherlands. Some characteristics of the motivational spaces might be specific to the Dutch institutional environment – its university regulations, academic career procedures, science policies and research council operations. Research is needed to examine whether these findings could be generalized to other countries given cross-country differences in institutional and careers arrangements.

References

- Aghion, P. and Tirole, J., (1994). The management of innovation. *Quarterly Journal of Economics*, 109, pp.1185–1209.
- Azagra-Caro, J.M., Carayol, N., and Llerena, P., (2006). Patent Production at a European Research University: Exploratory Evidence at the Laboratory Level, *Journal of Technology Transfer*, 31, pp.257–268.
- Baldini, N., Grimaldi, R., Sobrero, M., (2007). To patent or not to patent? A survey of Italian inventors on motivations, incentives, and obstacles to university patenting. *Scientometrics*, 70, pp.333–354.
- Baselli, S., and Pellicciari, F., (2007). *Academic Patents and technology transfer in the Netherlands. An empirical analysis*, Master Thesis, Faculty of Engineering, Brescia, Italy.
- Bekkers, R., and Bodas Freitas, I.M., (2008). Analysing knowledge transfer channels between universities and industry: To what degree do sectors also matter? *Research Policy*, 37, pp.1837–1853.
- Bercovitz, J., and Feldman, M. (2006). Entrepreneurial Universities and Technology Transfer: A Conceptual Framework for Understanding Knowledge-Based Economic Development, *Journal of Technology Transfer*, 31, pp.175-188.
- Bessen, J. & Meurer M. (2008). *Patent Failure*. Princeton: Princeton University Press.
- Bozeman, B. (2000), Technology Transfer and Public Policy: A Review of research and Theory, *Research Policy*, 29, pp.627-655.
- Bureth, A., and Pénin, J. (2007). Modular innovations and distributed processes: The case of genetically engineered vaccines, *European Journal of Economic and Social Systems*, 20(2), pp.251-274.
- Bureth, A., Levy, R., Pénin, J., and Wolff, S. (2005). Strategic Reasons for Patenting: Between Exclusion and Coordination Rationales, *Rivista di Politica Economica*, 95, pp.19-46.
- Cohen, W.M., Nelson, R.R., and Walsh, J.P. (2002). Links and Impacts: The Influence of Public Research on Industrial R&D, *Management Science*, 48, pp.1-23.
- Cohen, W.M., Nelson, R.R., and Walsh, J.P. (2000). Protecting their intellectual assets: appropriability conditions and why U.S. manufacturing firms patent (or not). Working paper no. 7552, National Bureau of Economic Research.
- Colyvas, J., Crow, M., Gelijns, A., Mazzoleni, R., Nelson, R., Rosenberg, N., and Sampat, B.N. (2002). How Do University Inventions Get Into Practice? *Management Science*, 48, pp.61-72.
- Czarnitzki, D., Hussinger, K. and Schneider, C. (2011). Commercializing Academic Research: The Quality of Faculty Patenting, *Industrial and Corporate Change*, 20(5), pp. 1403-1437.

- D'Este, P., and Perkman, M. (2011). Why do academics engage with industry? The entrepreneurial university and individual motivations, *Journal of Technology Transfer*, 36(3), pp.316-339.
- Fontana, R., Geuna, A., and Matt, M. (2006). Factors affecting university–industry R&D projects: The importance of searching, screening and signalling, *Research Policy*, 35, pp.309–323.
- Friedman, J., and Silberman, J. (2003). University technology transfer: Do incentives, management, and location matter? *The Journal of Technology Transfer*, 28, pp.17–30.
- Geroski, P.A. (2000). Models of technology diffusion, *Research Policy*, 29, pp.603-625.
- Geuna, A., and Nesta, L. (2006). University patenting and its effects on academic research. The emerging European evidence, *Research Policy*, 35, pp.790-807.
- Goldfarb, B. (2008). The effect of government contracting on academic research: Does the source of funding affect scientific output. *Research Policy*, 37(1), pp.41-58.
- Göktepe-Hulten, D., Mahagaonkar, P. (2010). Inventing and patenting activities of scientists: in the expectation of money or reputation? *Journal of Technology Transfer*, 34, pp.401–423.
- Hall, B.H., and Ziedonis, R.H. (2001). The Patent Paradox Revisited: an Empirical Study of Patenting in the US Semiconductor Industry, 1979-1995. *Rand Journal of Economics*, 32, pp.101-128.
- Henderson R., Jaffe, A.B., and Trajtenberg, M. (1998). Universities as a Source of Commercial Technology: A Detailed Analysis of University Patenting, 1965-1988. *The Review of Economics and Statistics*, 80(1), pp.119-127.
- Jensen, R.A., Thursby, J.G., and Thursby, M.C. (2003). Disclosure and licensing of University inventions: 'The best we can do with the s**t we get to work with', *International Journal of Industrial Organization*, 21(9), pp.1271-1300.
- Jensen, R., and Thursby, M. (2004). Patent Licensing and the Research University. *National Bureau of Economic Research*. Working Paper 10758. <http://www.nber.org/papers/w10758>.
- Lissoni, F., Llerena, P., McKelvey, M., Sanditov, B., (2008). Academic patenting in Europe: new evidence from the KEINS database. *Research Evaluation*, 17, pp. 87–102.
- MacLeod, C. (1988). *Inventing the Industrial Revolution. The English Patent System, 1660-1800*, Cambridge, Cambridge University Press.
- Manjarrés-Henríquez, L., Gutiérrez-Gracia, A. and Vega-Jurado, J. (2008). Coexistence of university–industry relations and academic research: Barrier to or incentive for scientific productivity. *Scientometrics*, 76(3), pp.561–576.
- Metcalfe, J.S. (2005). Ed Mansfield and the Diffusion of Innovation: An Evolutionary Connection. *Journal of Technology Transfer*, 30, pp.171-181.
- Metcalfe, J.S (1995). Technology systems and technology policy in an evolutionary framework. *Cambridge Journal of Economics*, 19(1), pp.25-46.

- Metlay G. (2006). Reconsidering renormalization: Stability and change in 20th Century views on university patents. *Social Studies of Science*, 36(4), pp.565-597.
- Minister of Economic Affairs (2003). Innovatiebrief. In actie voor innovatie. Aanpak van de Lissabon ambitie, Den Haag.
- Mowery, D., and Sampat, B.N. (2005). The Bayh-Dole Act of 1980 and University–Industry Technology Transfer: A Model for Other OECD Governments? *Journal of Technology Transfer*, 30, pp.115–127.
- OECD (2003). *Turning Science into Business. Patenting and Licensing at Public Research Organizations*, Paris: OECD.
- Owen Smith, J., Powell W.W. (2001). To patent or not: faculty decisions and institutional success at technology transfer. *Journal of Technology Transfer*, 26, pp.99-114.
- Penin J. (2005). Patents versus ex post rewards: A new look. *Research Policy*, 34, pp.641–656.
- Penin, J. (2010). On the Consequences of Patenting University Research: Lessons from a Survey of French Academic Inventors. *Industry & Innovation*, 17(5), pp.445-468.
- Slaughter, S., Campbell, T., Holleman, M., and Morgan, E. (2002). The ‘traffic’ in graduate students: graduate students as tokens of exchange between academe and industry. *Science, Technology & Human Values*, 27(2), pp.282–313.
- Verspagen, B. (2004). University Research, Intellectual Property Rights and the Dutch innovation systems, discussion paper for the Minister of Economic Affairs.
- Verspagen, B. (2006). University Research, Intellectual Property Rights and European Innovation Systems. *Journal of Economic Surveys*, 20, pp.608-632.
- VNSU (2012), Research Universities in the Netherlands, discussion paper, Amsterdam
- Welsh, R., Glenna, L., Lacy, W., Biscotti, D. (2008). Close enough but not too far: Assessing the effects of university–industry research relationships and the rise of academic capitalism. *Research Policy*, 37, pp.1854–1864.

Table 1. General information on the 16 projects that involved the publication of patents

Technology	Discipline	Funding	Size of research team	Starting	Time	Previous patents	Previous patents based on Univ. Knowledge	Previous Univ. owned patents	Number of OUTPUT patents	OUTPUT Univ. owned patents	Spin off
Flywheel	control system, mechanical engineering	R&D sponsoring of 60%	3	1997	5				2		End
guide-wire mounted sensor for measure pressure and temperature in the coronary artery	biomechanics and tissue engineering, biomedical engineering	mainly R&D sponsoring	2	2002	4	YES			1		
supervisory control of wafer scanners	systems engineering, mechanical engineering and mathematics and computer science	mainly private	1	2002	3				7		
rare earth activated-(oxy) nitride materials for LED applications	Materials and Interface Chemistry, chemical engineering and chemistry	half private half public	1	2001	2+3	YES	YES		2		
manufacturing method of photovoltaic foil	Plasma and Material Processing, Applied Physics	1st part R&D sponsoring; 2nd, 50% private; 3rd 100% private	5 to 8	1998	11	YES	YES	YES	12		
fully integrated in-line solar cell machine for high rate deposition of silicon Nitride	Plasma and Material Processing, Applied Physics	100% private	0.2	2002	2	YES	YES	YES	4		
method to lower the melt viscosity with nano-sized particles	Polymers and Functional Materials, Chemical engineering and Chemistry	public	1	2001	4+2	YES			1		
MIMO-OFDM for enhancing wireless local area networks	Radio communication, Electrical Engineering	mostly the firm, but also R&D sponsoring and university	2	1999	5	YES			10		

Composition analysis using low energy ions probing	Physics of Border Layers, Applied Physics	mostly public, several R&D sponsoring and some private financing	30	1981	16	YES			1		Impl.
stepper of a wide format printer	control system, mechanical engineering	university, firm	1	2004	1				1		
Actuators for deformable mirrors	control system, mechanical engineering	university, firm	1	2002	1+4				1	YES	
protein for cell apoptosis	Medical centre	private and research sponsoring	7	1989	7+3+5	YES	YES		23		Impl.
on-line measuring system of located partial discharges	Electrical Power systems, Electrical engineering	half private half public	2	2002	4				9		
inorganic phosphors as labels for antigens	Medical centre	public and R&D sponsoring	1	1986	5 +5+4	YES	YES	YES	0		
replication technology for biomolecules	Gene Therapy, Department of Molecular Cell, Biology	mainly R&D sponsoring but also venture capital	15	1992	10				1		Impl.
maskless lithography technique	Imaging Science and Technology, Applied Sciences	university and public R&D sponsoring	2	1998	1+2+7	YES			25	YES	Impl.

Table 2. Frequency and complementarity among Motivations for patenting. Spearman's correlation coefficients used to assess complementarity

	Traditional Motives			<i>Any Traditional Motive</i>	Heterodox Motives				<i>Any Heterodox Motive</i>
	1	2	3		5	6	7	8	
1 Securing benefits from future product development	1	0.13	-0.15	0.38	0.41	0.14	0.32	0.16	0.31
2 Guaranteed ownership of IPR on new products		1	-0.15	0.38	-0.14	-0.41	-0.22	0.16	-0.52*
3 Return on R&D investment from sale of innovation			1	0.1	-0.38	0	-0.33	0.15	-0.1
<i>Any Traditional Motives</i>				1	-0.26	-0.26	-0.29	0.17	-0.2
5 Signalling potential research partners					1	0.75**	0.63**	0.41	0.78**
6 Attracting research funds						1	0.38	0.67**	0.78**
7 Publication of valuable research results							1	0.22	0.68**
8 Attract venture capital								1	0.52*
TOTAL	11	11	2	15	8	8	7	5	10

Note 1: ** p<0.01, *p<0.05.

Table 3. Motivations for patenting and the characteristics of innovation. Frequency and linear associations measured by Spearman's correlation coefficients

		TOTAL	Proof of concept rather than developed crafted technology		Substitute rather than complementary to existing technologies	
			Observations	Correlation coefficient	Observations	Correlation coefficient
Traditional Motives	Securing benefits from future product development	11	7	0.405	9	0.418
	Guaranteed ownership of IPR on new products	11	4	-0.405	7	-0.164
	Return on R&D investment from sale of innovation	2	0	-0.378	0	-0.561*
<i>Any Traditional Motive</i>		<i>15</i>	<i>7</i>	<i>-0.258</i>	<i>10</i>	<i>-0.174</i>
Heterodox Motives	Signalling potential research partners	8	4	0.750**	8	0.674**
	Attracting research funds	8	8	0.750**	7	0.405
	Publication of valuable research results	7	7	0.630**	7	0.595*
	Attracting venture capital	5	7	0.405	4	0.164
<i>Any Heterodox Motive</i>		<i>10</i>	<i>8</i>	<i>0.775**</i>	<i>9</i>	<i>0.592*</i>
TOTAL		16	8		11	

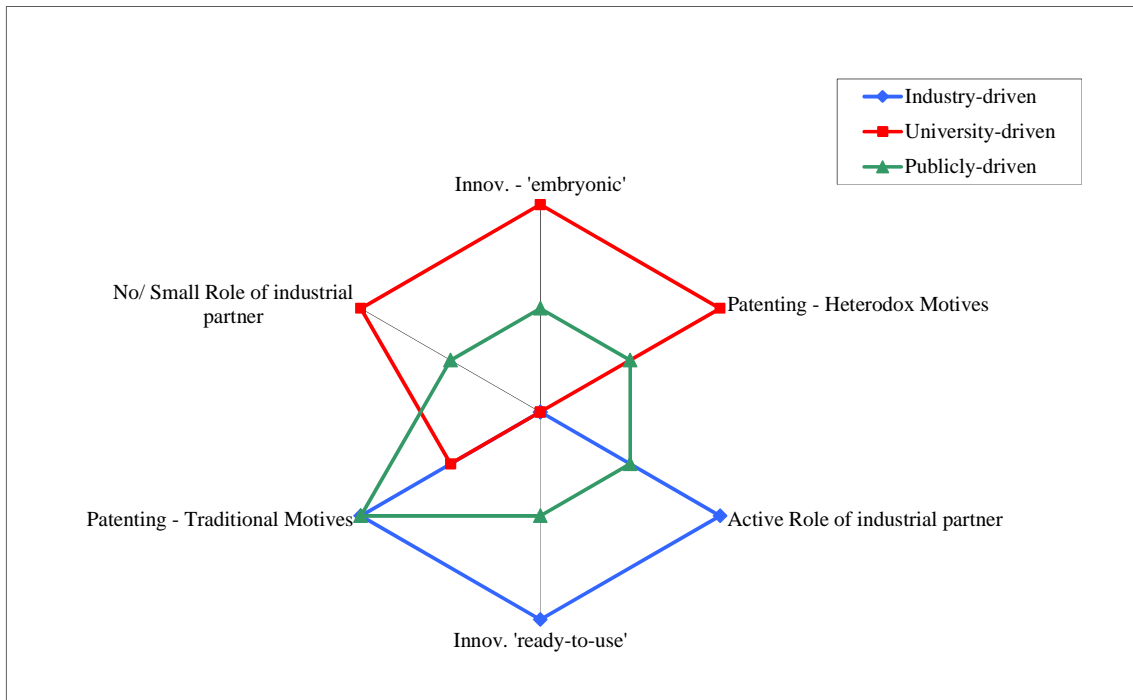
Note 1: ** p<0.01, *p<0.05.

Table 4. Motivations for patenting and the role of industrial partners in the research project. Frequency and linear associations measured by Spearman's correlation coefficients

		Firm participates on the design		Firm participates on the performance		Firm finances great part of the research project		TOTAL
		Observations	Correlation Coefficients	Observations	Correlation Coefficients	Observations	Correlation Coefficients	
Traditional Motives	Securing benefits from future product development	7	-0.164	5	0.051	2	-0.418	11
	Guaranteed ownership of IPR on new products	7	-0.164	7	0.595*	3	-0.127	11
	Return on R&D investment from sale of innovation	2	0.255	1	0.048	0	-0.255	2
<i>Any Traditional Motive</i>		10	-0.112	7	0.434^a	4	-0.383	15
Heterodox Motives	Signalling potential research partners	5	-0.135	3	-0.126	2	-0.135	8
	Attracting research funds	5	-0.135	2	-0.378	2	-0.135	8
	Publication of valuable research results	4	-0.221	2	-0.27	1	-0.323	7
	Attracting venture capital	3	-0.127	2	-0.051	0	-0.455^a	5
<i>Any Heterodox Motive</i>		7	-0.197	3	-0.269	2	-0.313	10
TOTAL		11		7		5		16

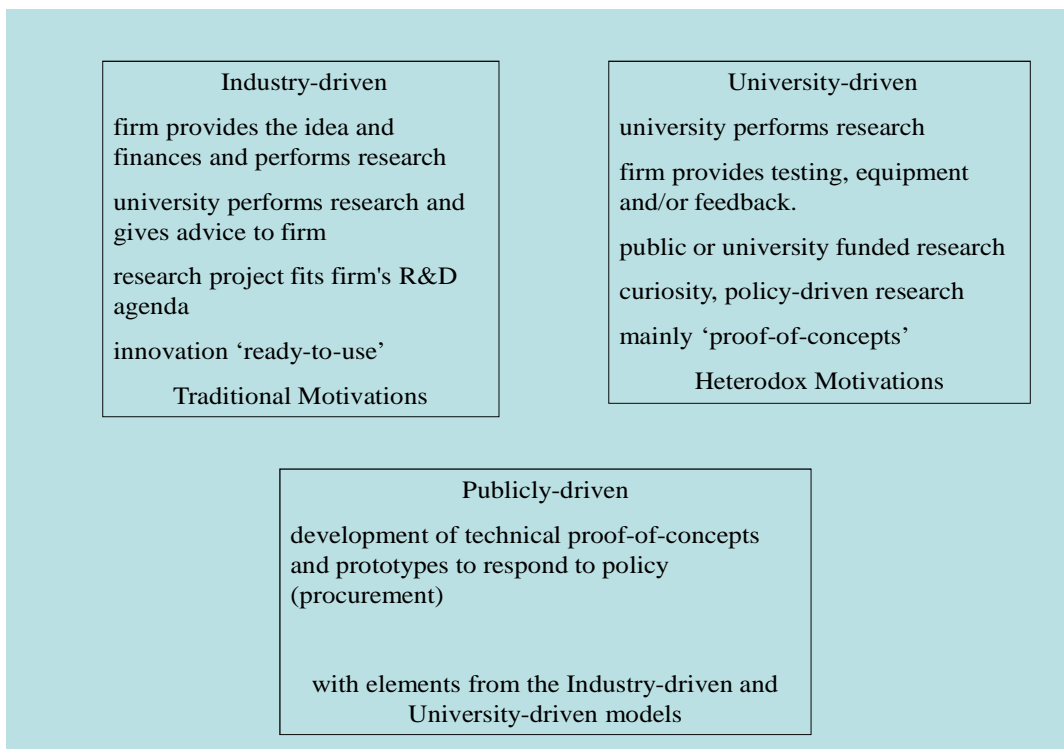
Note 1: ** p<0.01, *p<0.05, ^a p<0.1.

Figure 1: An Interpretative Framework for University Patenting



*Note: Elaboration by the authors based on the review of the literature

Figure 2: The three-pronged motivational space of university patenting



*Note: Elaboration by the authors