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**THE DETERMINANTS OF
TECHNOLOGY TRANSFER
EFFICIENCY AND THE ROLE OF
INNOVATION POLICIES: A SURVEY**

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The determinants of technology transfer efficiency and the role of innovation policies: a survey

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Abstract

The diversity found in the various Technology Transfer Offices (TTOs), besides being a consequence of the capacities and motives of the different stakeholders involved (public research organisations, industry, consulting firms and public authorities) also reflects the specificities of public incentives or policies and their differing degrees of commitment to technology transfer. Notwithstanding the fact that the literature on technology transfer is voluminous, few studies (up to the present date) have investigated the role of innovation policy on TTOs efficiency and the instruments available for governments to improve technology transfer from publicly funded research. The present paper surveys the literature on the determinants of TTOs efficiency, highlighting in particular the role of innovation policy. Additionally, evidence within the context of the European Union on innovation policies for technology transfer improvement is detailed.

Keywords: Technology transfer, innovation policies, technology transfer efficiency

JEL-Codes: O31; O34; O38

1. Introduction

Recognising the importance of improving knowledge transfer in the European Union (EU), motivated by the underperformance of Europe in comparison to the USA in terms of patents, licensing and spin-off creation, the European Commission (EC) launched a programme “Putting Knowledge into Practice” to help create an European framework for knowledge transfer (Siegel et al., 2007). The consistent emphasis by the EC on the coordination and diffusion of best practices in this area had repercussions at regional and national level with the implementation of several policy initiatives to foster knowledge transfer. Such policies aim to increase the transfer activities of public research organisations, to improve the regional coverage of innovation support services, to address the needs of particular target groups such as Small and Medium Enterprises (SMEs), or to provide a particular service such as patenting support (European_Commission(b), 2004).

Being considered the formal gateway between the university and industry, Technology Transfer Offices (TTOs) have been in the spotlight of research regarding the entrepreneurial university (Rothaermel et al., 2007). But, in recent years, attention shifted from studying the number and impacts of patents and licensing to understanding inter-institutional variations in the range and efficiency of technology transfer activities (Bercowitz et al., 2001).

The diversity found in the various transfer offices, besides being a consequence of the capacities and motives of the different stakeholders involved (public research organisations, industry, consulting firms and public authorities) also reflects the specificities of public incentives or policies and their differing degrees of commitment to technology transfer (European_Commission(b), 2004). Nevertheless, as stated by Rasmussen (2008), despite the voluminous literature on technology transfer, few studies have investigated the policy instruments available for governments aiming to improve technology transfer from publicly funded research (Rasmussen, 2008).

In the present study we undertake a literature review on the determinants of TTOs efficiency, focusing particularly on how Technology Transfer Offices (TTOs) efficiency is influenced by framework conditions, namely innovation policies. The paper is structured as follows: in the next section a review of international literature on the topic of technology transfer and the role of technology transfer offices is presented. Then, Section 3 introduces

the concept and evolution of innovation policies in the Europe and their relation to technology transfer. Finally, concluding remarks close the work.

2. Emergence and role of TTOs and the determinants of Technology Transfer efficiency

2.1. Clarifying the process of technology transfer

Technology transfer is at its infancy as a discipline and, as such, there is a lack of consensus and conceptual models, in the supporting literature, able to clearly define what is “Technology Transfer” and how does it occur (Stone, 2003). In the absence of a solid foundation in literature both “technology” and “transfer” are defined in different manners by different authors, according to their field of science and activity under study (Bozeman, 2000; Lane, 1999). As referred by Mings (1998: 3), “...we need more and plainer language as common reference points for widespread understanding of arguably one of the most important social, political, and economic trends of our time: technology transfer” (Mings, 1998). If in 1998 Mings was overwhelmed by the 100.000 results found in Internet for the words “technology Transfer” he would be surprised with the 23.700.000 results Google retrieves nowadays (March 2009).

For some the use of “technology” instead of “knowledge” is too restrictive and not representative of the full potential of the activity of transferring intangible assets. For instance, the Institute of Knowledge Transfer, in the UK, puts the tone in ‘Knowledge Transfer’, defined as “the systems and processes by which knowledge, including technology, know-how, expertise and skills, is transferred from one party to another leading to innovative, profitable or economic and social improvement”.¹ Because this knowledge may be tacit and specific to the entity that was involved in its creation and, hence, only partially appropriable to its receptor, technology transfer cannot be reduced to a linear “information transmission” and evermore should be considered as a process of reciprocal learning (Laranja, 2009).

Nevertheless, most definitions agree in characterising “technology transfer” as a process (cf. Figure 1), in which science or knowledge or capabilities are transferred or moved from one entity (person, group, organisation) to other for the purpose of further development and commercialization (Lane, 1999; Lundquist, 2003; Swamidass and Vulasa, 2008). The process usually includes the identification of technologies, its protection by patent or

¹ In: <http://www.ikt.org.uk/aboutikt.aspx>, accessed 21 December 2008.

copyrights and the development of commercialization strategies, such as marketing and licensing to existing private sector companies, or the creation of new start-up companies based on the technology (AUTM).²

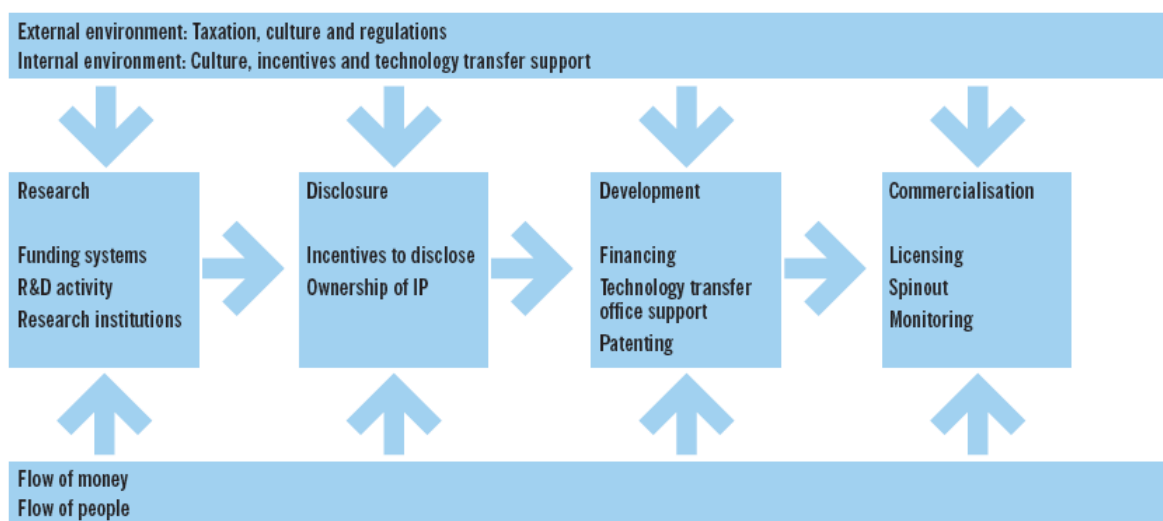


Figure 1: The process of technology transfer
Source: (APAX, 2005)

Technology transfer happens for a reason, it is a method for reaching goals, meeting needs and create wealth just as any other effort in business, government or academia (Lundquist, 2003). When this view is applied technology transfer becomes a logical, manageable, repeatable science (Lundquist, 2003). In its “rich vision” of technology transfer Lundquist (2003) attempts to clarify and provide a holistic description of technology transfer by searching answers for the questions: why, who, where, when, what, at what cost and how technology transfer occurs (cf. Table 1).

Table 1: A “Rich Vision” of technology transfer

Why?	Reason for transfer	“Technology is transferred to solve problems and create wealth”
Who?	Those doing transfer	“Technology is transferred by agents of change”
Where?	The environment for transfer	“Technology transfer occurs in value chains within or across corporate boundaries”
When?	Timing for transfer	“When barriers to transfer fall and both source and adapter of technology agree to move forward”
What?	Technology	“A unique source of value to its developers, adopters and eventual end customers”
At what cost?	Justification	“Transfer is cost justified by proving the unique and durable value of the technology to the company (transition) or the adopter (transfer)”
How?	Transfer	“Technology transfer works by engaging agents of change in a practical program built on deep understanding of technologies, technology management and marketing”

Source: In (Lundquist, 2003)

² In: <http://www.autm.net/aboutTT/index.cfm>, accessed at 7 November 2008.

Besides technology licensing and the creation of spin-off, there are several other mechanisms for technology transfer to occur. Graduate students carry knowledge from university into other sectors; publications and conferences allow industry to monitor new knowledge; faculty consulting leads inherently to the transfer of knowledge; the mobility of scholars has long allowed for exchange of knowledge and, more recently, the industry affiliate, program, research collaborations and interdisciplinary research centres have brought industry into campus with similar purposes (Goldfarb and Henrekson, 2003). As referred by Laranja (2009: 25), “no longer makes sense to think of unilateral transfer from supplier to recipient, but rather to regard technology transfer as a process, in terms of the recipient’s capabilities, including technical and organisational capacity to take on board ideas and technologies developed by others” (Laranja, 2009).

The European Commission (European_Commission(a), 2004) further adds that some pre-conditions must be fulfilled by the research organisation in order for technology transfer to occur, namely: (1) it must hold relevant state-of-the-art competence, be capable to produce it, or be in a position to provide applied research services for the implementation and adaptation of (cutting edge) technology developed elsewhere; (2) be motivated to transfer its knowledge and to communicate with enterprises and (3) establish a transfer mechanism that is transparent to the potential user and capable of combining and integrating (research) competences according to the needs of client enterprises.

2.2. The role of Technology Transfer Offices (TTOs)

Within the scope of BEST³ project, the European Commission (European_Commission(b), 2004), p. 10), defines TTOs as “...institutions which provide, continuously and systematically, services to publicly funded or co-funded research organisations in order to commercialise their research results and capacities. They are instruments to further the dissemination and the uptake of new technologies by enterprises”. Link et al. (2003) agree that TTOs facilitate technological diffusion through the licensing to industry of inventions or intellectual property resulting from university research (Link et al., 2003).

TTOs contribute to faster and better commercialisation of research results; they improve innovation performance and accelerate the dissemination of new technologies; lead to better management of intellectual property rights and identify specific research demands

³ BEST “Evaluating Dissemination and Quality of Institutions for the Technology Transfer from Science to Enterprise (ITTE), was a DG Enterprise -project under the Multi-annual program (MAP – ITTE 1.11/2002). As part of the project, a study contract had been tendered to a consortium of inno AG, Logotech and Angle Technology, which subsequently conducted a survey of TTIs in Europe.

through dialogue with industry (European_Commission(b), 2004; Siegel et al., 2003). In general, services provided by TTOs (cf. Figure 2) cover patenting and intellectual property management, including activities necessary for the filing of a patent and the management of other forms of intellectual property; licensing of intellectual property rights; liaising with industry for collaborative and contract research, including client recruitment, contracting, and contract management; supporting spinouts, including business planning and fund raising; and potentially financing spinouts by providing seed capital (European_Investment_Fund, 2005).

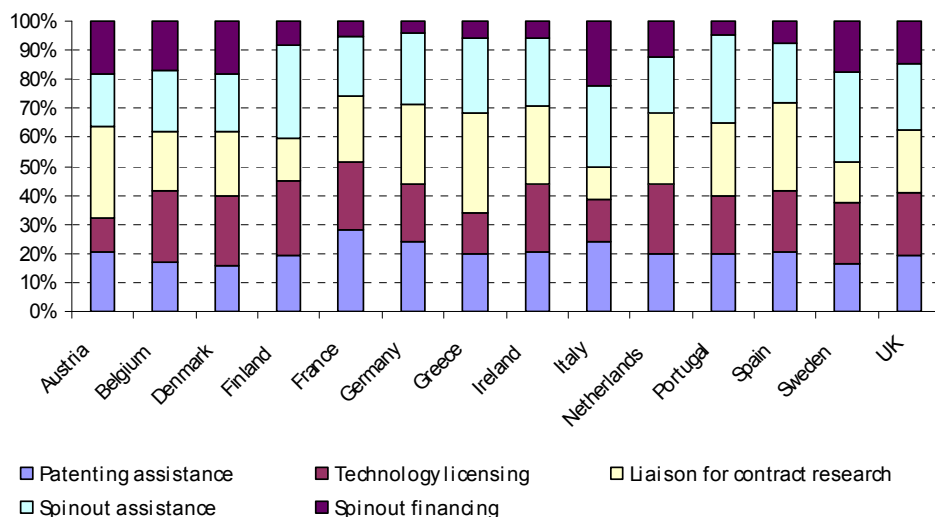


Figure 2: Services provided by Technology Transfer Offices (% of TTOs providing the service)
Source: Computed by the author based on data from (European_Commission(b), 2004)

The European Investment Fund (2005) refers that TTOs as intermediary structures, favour a more efficient division of labour. By investing in the required expertise, TTOs allow inventors, for whom the main comparative advantage is creativity or specific knowledge, to avoid devoting time and resources to commercialising their inventions, and hence reduce transaction costs and improve allocative efficiency (European_Investment_Fund, 2005). Furthermore, their activities have important economic and policy implications since licensing agreements and spin-offs may result in additional revenue for the university, employment opportunities for researchers and graduate students and local economic and technological spillovers reflected in the stimulation of job creation and additional R&D investment (Siegel et al., 2007).

The creation of a specialized and decentralised TTO within the university is instrumental to secure a sufficient level of autonomy for developing relations with industry (Debackere and Veugelers, 2005; Macho-Stadler et al., 2007). Additionally, it allows a better management of possible conflicts of interest between the activities of commercialisation,

research and teaching, whilst creating the conditions for a specialisation in supporting services such as management of intellectual property rights and business development (Debackere and Veugelers, 2005).

For Colyvas et al. (2002), in many cases, the role of such offices is not to create links between the university and industry but rather to facilitate, mediate and regulate the transactions that already take place between parties that already knew each other (Colyvas et al., 2002). In such cases, the value and costs of operating these offices is inherently the result of the university policies to file, enforce and licence patents on their inventions (Colyvas et al., 2002). Their assumptions were, however, based on the study of the licensing efforts of Stanford and Columbia University, two worldwide renowned institutions with secure links with industry, the role of TTO in less emblematic universities may very well turn out to be the only channel through which industry may learn about research commercialisation opportunities.

The TTOs may adopt several organisational set-ups depending on the hosting university directives, objectives to achieve and policies in place. The most common typologies include: organisational units or specialised departments operating within the university, wholly owned subsidiaries operating outside the university and public or private structures serving a larger group of universities or research institutions (European_Commission(a), 2004). The institutional type chosen reflects factors such as the legal environment (ownership arrangements of IPR), the degree of institutional autonomy of PROs, the PRO's legal status, or the amount of public funding available for the TTO (European_Commission(a), 2004). This diversity may be faced as a natural experiment in which the various actors search for efficient means to organise their activities to promote both the diffusion of university research and the generation of additional revenue, while maintaining the traditional university mission of creating knowledge and educating students (Bercowitz et al., 2001).

2.3. Measuring relative efficiency of TTOs

The linkages between science and industry, and the effectiveness and efficiency of these linkages for a smooth transfer of knowledge are many-faceted and difficult to measure and evaluate (European_Commission, 2001). According to Sorensen and Chambers (2008), defining success in academic technology transfer is a function of selecting what outcomes are desired and then measure performance in light of those outcomes. Most authors aim at

evaluate the efficiency of a TTO based on the study of tangible outputs of university research and typically with respect to patenting, licensing and spin-off creation. As referred by Anderson et al. (2007) the simplest method to measure TTOs efficiency would be to rank universities based solemnly on their licensing revenues.

According to the microeconomic literature (Thursby and Kemp, 2000) a producing unit is 'technically inefficient' if it is possible to produce more output with the current level of inputs or, equivalently, it is possible to produce the same output with fewer inputs. As Thursby and Kemp (2000) point out, in universities the reasons for technical inefficiency include, among other things, the failure to take advantage of all commercialisable IP as well as a greater preference for basic over applied research.

In their unusually comprehensive literature analysis (173 articles) on university entrepreneurship, Rothaermel et al. (2007) refer quantitative methods as the most often used when studying the efficiency of TTOS (63% of articles). These methods are based on the construction of a "best practice" frontier, the distance to which represents the inability of a structure to generate maximal output from a given set of inputs (Chapple et al., 2005; Siegel et al., 2007). Two methods are used to estimate these frontiers, Data Envelopment Analysis (DEA) and Stochastic Frontier Estimation (SFE) (Siegel et al., 2007). DEA is a non-parametric approach that obviates the specification of a functional form for the production frontier (Siegel et al., 2003). It allows to handle multiple outputs and to identify "best practice" universities" (Chapple et al., 2005) and can also cope more readily with multiple inputs and outputs than parametric methods (Siegel et al., 2003). The major drawback of DEA is that it is deterministic and highly sensitive to outliers which means that it does not allow to distinguish between technical inefficiency and noise (Chapple et al., 2005). SFE allows for statistical inference about the impact of independent variables but requires restrictive functional form and distribution assumptions, being limited when a multi-output approach is required (Siegel et al., 2003). It allows hypotheses testing and construction of confidence intervals (Chapple et al., 2005). This approach is useful when there is more interest in estimating average relationships than in identifying outliers for diagnostic purposes (Chapple et al., 2005). DEA and SFE can generate different results particularly when high levels of heterogeneity and noise are present in the data (Chapple et al., 2005). For Siegel et al (2003) both methods are complements and not substitutes.

Anderson et al. (2007) used an output oriented DEA model, including weight restrictions, to access the productivity of selected US University TTOs. An examination of differences

between public versus private universities and those with medical school and those without indicated that universities with medical schools are less efficient than those without (Anderson et al., 2007). Thursby and Kemp (2002) employ DEA combined with regression analysis to explore the increase in licensing activity of U.S universities as well as the productivity of individual universities. They found that licensing activity had increased over the years by others factors than increases in overall university resources (Thursby and Kemp, 2000). Siegel et al. (2003) present a quantitative analysis of efficiency, measuring the relative productivity of TTOs in the U.S using a parametric approach (SFE). Their findings suggest that TTO activity is characterized by constant returns to scale and that the variation in performance is explained by environmental and institutional factors. Chapple et al. (2005) present evidence on the performance of TTOs in the U.K. using both DEA and SFE approaches; they found that there is a need to increase the business skills and capabilities of TTO managers and licensing officers.

2.4. Determinants of successful technology transfer

Efficiency in technology transfer is a function of converting inputs to outputs by the involvement of one or more agents or stakeholders, namely researchers, TTOs, entrepreneurs and private industries (Anderson et al., 2007) (Figure 3). In technology transfer the most often referred inputs consist of R&D expenditure (Conti et al., 2007; OECD, 2008), either originated from private or public sources, and research results in the form of invention disclosures (Chapple et al., 2005; Conti et al., 2007). As for outputs, most authors (Anderson et al., 2007; Chapple et al., 2005) agree in categorising licensing income, number and income of industry sponsored research contracts, number of patents granted and number of spin-offs created as the main outputs of university/industry technology transfer. The efficiency of this conversation may be hampered or stimulated by a series of factors also known as determinants of technology transfer efficiency. Mainstream literature aggregates technology transfer determinants in two major categories. The first is internal conditions, such as organisational structure and status (Anderson et al., 2007; Bercowitz et al., 2001; Thursby and Kemp, 2000), size (Anderson et al., 2007; Macho-Stadler et al., 2007), rewards or incentives (Anderson et al., 2007; Friedman and Silberman, 2003; Siegel et al., 2003), age or experience (European_Commission(b), 2004; Swamidass and Vulasa, 2008), nature and stage of technology (Colyvas et al., 2002; Rothaermel et al., 2007), culture and norms of behaviour (Anderson et al., 2007; Bercowitz et al., 2001) and links to industrial partners (Colyvas et al., 2002; Swamidass and Vulasa,

2008). The second is external or framework conditions including location (Chapple et al., 2005; Conti and Gaule, 2008; Friedman and Silberman, 2003), context (Debackere and Veugelers, 2005; Siegel et al., 2003), specific legislation and regulation (OECD, 2004) and public policies (Bozeman, 2000; European_Commission, 2001; Goldfarb and Henrekson, 2003; OECD, 2004).

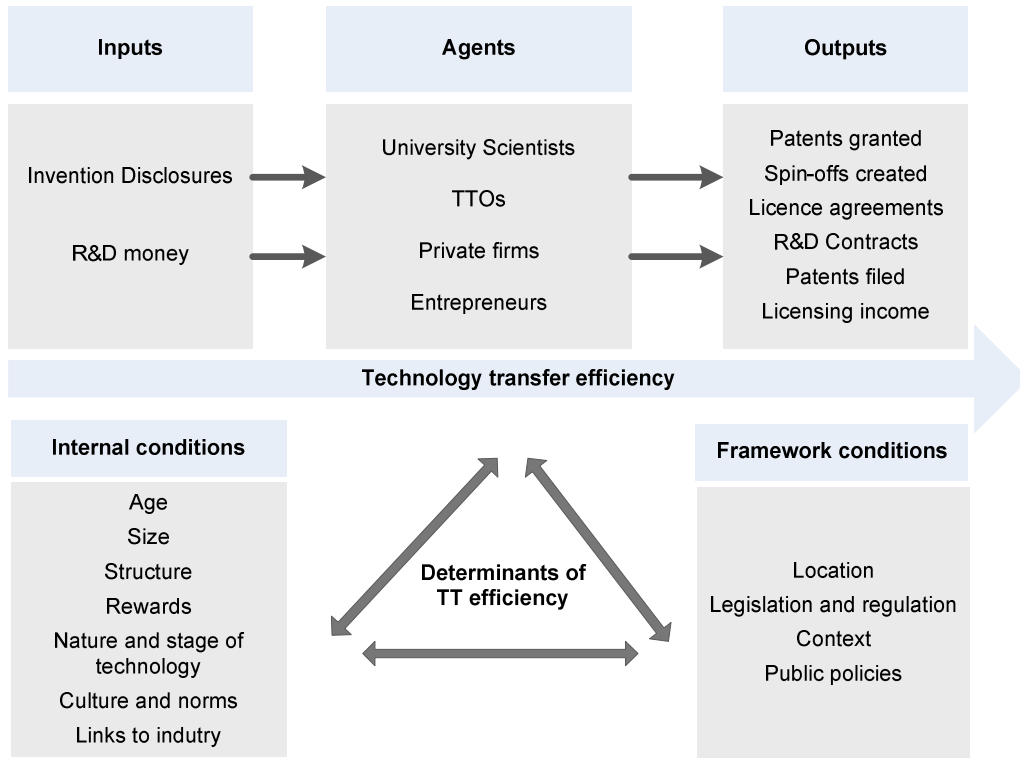


Figure 1: Technology transfer efficiency

Source: The authors

Several factors have been pointed as having influence in explaining the success in technology transfer and the relative efficiency of TTOs, among which (Rothaermel et al., 2007): technology transfer systems, structure and staffing, nature and stage of technology, faculty, university system and environmental factors. Table 2 summarises the main determinants of technology transfer offices efficiency found in the literature.

It takes considerable time to successfully license or market good university inventions that on a short run do not generate cash flow for the licensing companies (Swamidass and Vulasa, 2008). A direct correlation between age and performance of technology transfer activity was also described by the European Commission (European_Commission(b), 2004), when assuming that to build up a large portfolio of patents and generate high yearly licence revenues is a time consuming activity, so the more mature a TTO is the more probable to have a history of at least moderately successful activity and survival. Most

technology transfer offices in Europe exist for less than 10 years and are still not self-supporting. Proton Europe 2004 Annual Survey to European university TTOs, confirms this trend with 60% of respondents reporting to have been created in the last 10 years (Proton-Europe, 2005).

A relevant implication is that in times of university budget deficits TTOs may face budget cuts which, in turn, may erect capacity barriers to the smooth flow of inventions to the market making their activity even more challenging (Swamidass and Vulasa, 2008). The budget allocated to the TTO, influences the number of personnel employed in invention evaluation and marketing, staff trained, the information technology (IT) infrastructure to help automate the process and the overall success in technology transfer (Swamidass and Vulasa, 2008). Also trust and visibility, which are important success factors for TTOs and which need time to develop, correlate with age as well as the accumulation of knowledge, some of it tacit, and the development of a social network (European_Commission(b), 2004).

Another particular success factor for the TTOs is the awareness about technology transfer, which they are able, in general, to create among researchers in the institution (European_Commission(b), 2004). University researchers are the suppliers of innovations since they are the ones involved in the creation of knowledge while conducting research projects (Siegel et al., 2007) hence, the potential of a public research organisation can only be fully exploited if researchers are conscious of research results valorisation, have sufficient incentives to engage in commercialisation and industry collaboration and hence actively disclose inventions and contribute to contract research (European_Commission(b), 2004).

Table 2: Determinants of technology transfer offices efficiency.

Determinants	Study	Research questions	Method	Variables	Key findings
Structure and status	(Anderson et al., 2007)	Is there a relationship between university efficiency and the existence of a medical school using linear regression? Are private universities more (or less) efficient than their public counterparts in terms of technology transfer?	Data envelopment analysis (DEA) approach is used as a productivity evaluation tool applied to university technology transfer. The methodology included weight restrictions providing a more comprehensive metric.	An examination of differences between public versus private universities and those with medical schools and those without.	The results obtained indicate that public versus private status and the presence of a medical school do not explain the variations obtained in technology transfer efficiency amongst the 52 universities analysed. Universities with medical schools are less efficient than those without.
	(Chapple et al., 2005)	What is the performance of UK university technology transfer offices? Do different methods (non-parametric and parametric) result in different conclusions?	50 UK universities	The annual number of licensing agreements consummated by the university, annual invention disclosures/total research income	Invention disclosure, total research income, the number of technology transfer employees, and protection of licensee affect TTO's licensing performance. Regions with a higher R&D intensity, younger TTOs, and universities with medical schools are more efficient at generating new licenses. Parametric methods results in higher efficiency measures than those of non-parametric.
Staffing capacity	(Swamidass and Vulasa, 2008)	Is staffing shortages in university TTOs a performance limited constrain?	Survey questionnaire sent to 99 randomly selected US research universities	(1) Education and experience (2) Staff size and shortage (FTE) (3) staffing and tech transfer performance in terms of provisional applications and licensing agreements (4) The percentage of inventions that do not get processed due to the lack of personnel (5) The budget allocated for invention commercialization	When short of staff and budget university TTOs will be reduced to devoting their resources to ensuring patent applications are filed and granted at the expense of marketing inventions
	(Machostadler et al., 2007)	n/a	Theoretical model to explain the specific role of Technology Transfer Offices (TTOs) in licensing university inventions	n/a	TTO is often able to benefit from its capacity to pool innovations across research units (and to build a reputation) within universities Importance of a critical size for the TTO to be successful as well as the stylized fact that TTOs may lead to fewer licensing agreements but higher income from innovation transfers.

Determinants	Study	Research questions	Method	Variables	Key findings
	(Siegel et al., 2003)	How do stakeholders of university-industry technology transfer (UITT) define the outputs of the process? What are the organizational/managerial barriers to UITT?	Based on 55 interviews of 98 entrepreneurs, scientists, and administrators at five research universities	n/a	TTO activity is characterized by constant returns to scale and by environmental and institutional factors. Productivity may also depend on organizational practices. Unfortunately, there are no quantitative measures available on such practices, so they conclude that the most critical organizational factors are faculty reward systems, TTO staffing/compensation practices, and cultural barriers between universities and firms.
Organizational practices/structure	(Bercowitz et al., 2001)	How organisational structure mediates the relationship between inputs that give rise to IP and the level and forms by which the university generates revenues from it?	21 interviews conducted in 3 universities with technology transfer personnel, faculty and research administrators. The interview protocol was loosely structured to allow open responses. Documentation on policy statements, organizational charts and history was also collected.	The structure of TTO provides a set of organisational variables that may be used to explain technology transfer outcomes across universities, namely: Information processing capacity (yield as measured by invention disclosures/TTO, licensing/TTO, sponsored research agreements/TTO), Coordination capabilities (likelihood that research firms will be shared” Incentive alignment properties ((trade-off between royalty rate/licensing fees)	Structure affects performance in a predictable manner.
	(Debackere and Veugelers, 2005)	How do technology transfer mechanisms evolve to contribute into an effective commercialization of academic science base?	Katholieke Universiteit Leuven R&D	n/a	Framework of governance structure that captures the formation of effective mechanisms: an appropriate organizational structure (e.g., unambiguous regulation of ownership titles and property rights, appropriate mix of incentive mechanisms targeted to the research group and individual researchers, decentralized management style, a matrix structure for the interface/ liaison), process (e.g., a well-balanced process to manage and monitor contract research), and context (e.g., active management policy) within university

Determinants	Study	Research questions	Method	Variables	Key findings
Budget	(Trune and Goslin, 1998)	Do the economical benefits of maintaining a TT program outweigh the related financial burden (salaries, overheads, patenting...)	Data from the 1995 AUTM licensing survey, from which estimates of the benefits and costs of maintaining a TTO were made.	The criteria used to provide the estimates: - Technology transfer office (n° of staff, salaries and overhead) - Patent costs - New research grants - Royalties	On a national scale the technology transfer programs appear to be making money for some institutions and providing benefits to their local communities. Although only half of the universities are operating profitably this may be due to the short term (5 to 10 years) their programs have been in operation. Government initiatives encourage a bottom up approach. This is accomplished by providing resources for direct use in commercialization projects or to develop professional expertise in technology transfer in the university sector, by experimenting with new initiatives, and finally by facilitating cooperation between commercialising organizations
	(Rasmussen, 2008)	How can government instruments facilitate the commercialization of university research based on the Canadian case?	Case study of the variety of national government initiatives available in Canada, and how these initiatives are operated.	n/a	Factors enhancing university TT: greater rewards for faculty involvement in TT, proximity to regions with concentration of high-tech firms, a clear mission in support of TT, and the experience of technology transfer office. The number of invention disclosures influences licensing agreements, while faculty quality affects the number of disclosures
Policy/contextual-related factors	(Friedman and Silberman, 2003)	What are the characteristics of research universities that affect the number of invention disclosures? What are the university policies, incentives, regional and local characteristics that affect the technology transfer output?	AUTM, National Research Council, universities' published policy on distribution of royalty income Invention disclosure, licenses executed, licenses generating income, cumulative active licenses, license income	n/a	Top-down nature of Swedish policies of commercializing university inventions and Swedish academic environment discourage academics in actively participating in the commercialization of their inventions. US institutional setting, characterized by competition among universities for research funds and scientists, has led to a more active commercialisation of faculty inventions.
	(Goldfarb and Henrekson, 2003)	What are the national policies that are most efficient in promoting the commercialization of university-generated knowledge?	n/a	n/a	

University inventors which do not have ties to potential industrial licensees make the technology marketing a considerable more challenging task for the TTOs (Swamidass and Vulasa, 2008). The researchers involved in successful technology transfer cases were, in most cases, active members of a community, a network of scientists that involved people from the industry who were aware of the research projects, sometimes from its inception, and that most likely could benefit from the application of such results (Colyvas et al., 2002).

The stage of development of an invention seems also to have a direct implication in the strategy that should be adopted to bring it to industry. Colyvas et al. (2002) observed that for emergent technologies intellectual property rights and exclusive licences appeared to be relevant for inducing firms to engage in the development of the invention while not as important for “off the shelf” technologies; however, the authors also claim that for embryonic inventions the dangers of strong exclusivity are higher since it is never clear so in advance which firm will have the capability to successfully develop the additional work.

Institutional history, culture and norms of behaviour, while not sole determinants of the structure of the TTO, appear to play an important role in the universities’ approach to technology transfer (Anderson et al., 2007; Bercowitz et al., 2001). Differences amongst intellectual property rights policies in Universities may very well be one of the critical factors stifling university-industry links and the efficiency of the TTO (Anderson et al., 2007; Debackere and Veugelers, 2005). Within each university intellectual property regulations vary greatly, with some taking total ownership of any know-how generated with its resources and others granting the rights to the individual researcher and/or R&D centre. Colyvas et al. (2002) based on their work on how university patents get into practice, suggest that in contexts where other means of appropriability by the companies are present patentability and exclusive licences of the university research may be less essential. There is, however, one major distinction between patents issued by companies, that patent mostly in areas relevant to their activity and for internal consumption and patent filed by universities who need to find external licensees for their issued patents, an expensive and time consuming task (Swamidass and Vulasa, 2008).

Another major issue is whether researchers have sufficient incentives to disclose their inventions to the TTO and to induce their further collaboration during and after the licensing agreement (Debackere and Veugelers, 2005; Siegel et al., 2007). In order for the university to generate an economic flow from the transfer of intellectual property first the faculty members

must disclose their inventions to the TTO (Link et al., 2003). Technology Transfer Offices must access a critical mass of inventions by pooling a sufficient number of inventions originating from different laboratories or research organisations (European_Investment_Fund, 2005). In reference to the work of Thursby (2001), Link et al. (2007) claim that many TTOs report that only half of the potentially viable commercial inventions are actually disclosed. This creates discrepancies in TTO performance that, as referred by Siegel et al. (2007), may in turn highlight the problems for technology transfer officers in eliciting disclosures.

On the other hand, not all disclosed and potentially viable inventions will be protected and licensed by the University. Siegel et al. (2007), draw attention to the problem of asymmetric information on the value of the inventions between industry and researchers. While industry has problems in foreseeing the quality of the invention *ex ante*, researchers may find it difficult to assess the commercial profitability of their inventions (Debackere and Veugelers, 2005; European_Investment_Fund, 2005; Siegel et al., 2007).

Anderson et al. (2007), quoting Siegel et al.'s (2003) work, also link the productivity of TTOs to their organisational structure and, in particular, the existence or not of faculty reward systems, TTO staffing compensation practices, and cultural barriers between universities and firms. The authors also point out to the possible influence of scale size of TTO and if there is a dimension below which successful technology transfer is difficult to occur (Anderson et al., 2007; Macho-Stadler et al., 2007). Smaller universities often lack the level of resources and expertise necessary to effectively support the creation of a TTO (Debackere and Veugelers, 2005). For Bercowitz et al. (2001), one common complaint heard from the TTOs interviewed is the understaffing of their offices (Bercowitz et al., 2001). Achieving a critical size is also crucial to support the sunk costs needed to acquire the required expertise for identifying new inventions and sorting out profitable from unprofitable ones (European_Investment_Fund, 2005). Alongside, further research should be done to clarify if the organisation structure and operational processes/policies of the TTO as well as the level of support given by the university administration may impact the technology transfer efficiency (Anderson et al., 2007).

Although, organisational factors, as for cultural barriers between universities and small firms, incentive structures in the form of pecuniary and non-pecuniary rewards and staffing and compensation practices of the TTO, tend to be the most relevant impediments to effective university technology transfer, they cannot by itself explain divergences in TTO performance (Siegel et al., 2007). Environmental and institutional factors are also likely to be important

determinants of relative performance (Siegel et al., 2007). These are characterised by Debackere and Veugelers (2005) as “context” related to the institutional and policy environment, the culture, and the history that has unfolded within the academic institution (Debackere and Veugelers, 2005) and by the European Commission (2001) as “Framework conditions”, covering all those factors which affect the behaviour of actors and institutions in industry and science, which are involved in knowledge and technology exchange activities (European_Commission, 2001). The "policy-related framework conditions" refer to those factors which are strongly shaped by policy decisions or may directly be designed by policymakers, namely public promotion programmes and initiatives, henceforth referred as innovation policies.

In fact, fostering the direct commercialisation of research results in public science has been an important policy issue, especially in fields such as biotechnology, genetic engineering, new materials, and new information and communication technologies (European_Commission, 2001). Thus, various initiatives have been proposed or implemented, by different countries, to increase the incentives and commitment of universities to transfer technology to the private sector. In a number of countries, policymakers have even gone further, enforcing technology transfer as one of the missions of Universities, as for the case of Denmark’s new University Act which integrates knowledge and technology transfer as part of the universities’ charters (European_Investment_Fund, 2005).

3. The role of innovation policies in fostering technology transfer

3.1. From national to transnational: concept and emergence of EU innovation policy

The European Commission (2000: 9) defines innovation policy as “...a set of policy actions to raise the quantity and efficiency of innovative activities, whereby “innovative activities” refers to the creation, adaptation and adoption of new or improved products, processes, or services...” (European_Commission(b), 2000). The INNO-Policy Trendchart further adds that Innovation policy measures are defined as any activity that mobilises: (1) resources (financial, human, and organisational) through innovation orientated programmes and projects; (2) information geared towards innovation activities and (3) institutional processes (legal acts, regulatory rules) designed to explicitly influence environment for innovation (European_Commission(a), 2008). In short, public innovation policy aims to strengthen the competitiveness of an economy or of selected sectors of it, in order to increase societal

welfare through economic success (Kuhlmann and Edler, 2003), by stimulating, guiding, and monitoring knowledge-based activities within a political jurisdiction (Mothe, 2004).

Being an integral part of the innovation system, understood here as the interconnections of institutions, corporate actors and processes contributing to industrial and societal innovation, “innovation policies” are multifaceted, ingrained and wide ranging, including all state initiatives regarding science, education, research, technology development and industrial modernisation and which may also overlap with industrial, labour and social policies (Kuhlmann, 2001; Kuhlmann and Edler, 2003; Shapira et al., 2001). Furthermore, they can be developed and implemented at various levels: local, regional, national and European (European_Commission(b), 2000). They are executed by a wide range of differentiated innovation policy instruments, reflecting the scope of institutions and interests involved, as for: various forms of financial incentives for research institutions; the conducting of research and experimental development in public or industrial research labs; the design of infrastructure, innovation clusters and poles, including the institutions and mechanisms of technology transfer (Kuhlmann, 2001).

Innovation policies emerged to offset “market failures” reflected in insufficient allocation of funding for risky and innovative investments (European_Commission(a), 2008). Nevertheless, evidence suggests that in practice innovation policy is driven by a much more diverse set of issues (European_Commission(a), 2008). Recently the theory of market failure as a basis for policy has been extended to include the notion of “systemic failures”, which take into account not only the key deficiencies of companies but also failures in capabilities, behaviour, institutions and framework conditions which damage system performance and justify intervention (Arnold, 2004). Table 3 describes the main typologies of failures in innovation systems found in literature. Innovation policy challenges will further built upon the failures indicated in this table.

In terms of chronological evolution, for most OECD countries, it was the Second World War, and after that the national security considerations and the Cold War which settled the stage for a technology burst of development, the close collaboration of industry, universities and government and the links between science and technology (Freeman, 2003).

Policies for the development of science and technology which had up until then been sporadic and relatively small-scale, became recognized as a regular requirement of government, at first in the military field but soon for civil industry as well (Freeman, 2003; Lemola, 2002). During

the following 40 years, policies and instruments for the funding of R&D have shown an irregular evolution and development, reflecting budgetary constraints, the outcomes of political compromises, and prevailing ideas about what a European science and technology policy should be (Pavitt, 1998).

Table 3: Main typologies of innovation systems failures

Market failure	Three prime sources for market failure coexist (Falk, 2007): (1) the appropriability problem, translated into innovating firms bearing high costs when generating new knowledge that spills over to society, competing firms included, and hence cannot reap the full benefits thereof; (2) the key generation of knowledge may require a scale of effort larger than individual firms alone could generate or sustain and (3) risks and uncertainties associated to initial investments while markets that insure against these risks either do not exist or they do not function properly due to information asymmetries.
Capability failure	Inadequacies in the ability of companies to act in their own best interest due to managerial deficits or technological deficits (Arnold, 2004).
Failure in institutions (norms and regulations)	Inability of other actors of the national innovation system to work properly, for instance due to rigid rules that might hinder change or adaptation in universities (Arnold, 2004).
Network failures	Problems in the interactions among actors in the innovation system such as inadequate amounts and quality of interlinkages (Arnold, 2004).
Framework failures	Gaps and shortcomings of regulatory frameworks health and safety rules, IPRs as well as other background conditions, such as the sophistication of consumer demand, culture and social values (Smith, 2000).
Policy failure	Reflected in activities to enhance the policy process and to induce policy learning (European_Commission(a), 2008).

Despite the emerging importance of stimulating R&D and the development of technological competitive advantage over the USA and Japan, neither industrial policy nor research and development policy were among the areas covered in the 1967 Treaty of Rome (Mytelka and Smith, 2002). It was not until the 1970s that industrial policy turn into an area of activity for the European Union (EU) and that science and technology become linked with such policy (Georghiou, 2001; Grande and Peschke, 1999), but still regulation and support of high technology sectors and R&D policy occurred almost entirely at the national level in EU member states (Gulbrandsen and Etzkowitz, 1999). In fact, until recently, the innovation policies of European countries clearly reflected the profiles of their national (and regional) innovation systems (Kuhlmann, 2001). But is also true that frontiers are permeable and countries copy and learn from each other, as a consequence policies increasingly follow a

transnational tendency. These developments have both been influenced and reinforced by the rise of transnational public programs of R&D support, such as Eureka, the Framework Programme, which arose in response to a situation where individual R&D activities were uncoordinated and required a large number of Council decisions, and the increasing activity of organizations such as the European Commission (Georghiou, 2001; Grande and Peschke, 1999; Lemola, 2002).

With the Single European Act and the Maastricht Treaty, the EU innovation policies acquired a legal basis and enlarged scope (Grande and Peschke, 1999). Still, EU policies must, officially, be concentrated on the creation of “European added value” (Kuhlmann, 2001) and must obey two guiding principles: the “subsidiarity principle” proclaiming that whatever can be done at the local governmental level, should be done at the local governmental level and the “additionality principle” by which if a policy can be reproduced at national level it should not be undertaken (European_Commission(b), 2000).

The influence of EU policy on the national level is of relevance to each Member State to varying extent including, but not limited to, the influence of the Lisbon Strategy, the influence of the Framework Programme and the influence of the structural funds, which all together may impact on national strategy formulation or on the implementation of instruments as well as more structural elements of the governance system such as evaluation procedures (Whitelegg et al., 2008). The decision, in the March 2000 Lisbon European Council, to create a European Research Area (ERA), further emphasised the need for programmes and policies implemented and funded at European level as well as effective European-level coordination of national and regional research activities (European_Commission, 2007). The impact of such reform was visible on the compromise of all Member States in setting national R&D investment targets in the context of the overall EU 3% of GDP R&D investment objective (European_Commission, 2007).

National as well as transnational innovation policy governance is characterised by, more or less, formalised “negotiations” between multiple self-interested groups of actors, (industries, research and education institutions, policymakers, etc.) that coexist in innovation systems (see Figure 4) (Kuhlmann, 2001).

In this context, linking science and industry in a systematic way without jeopardizing the necessary autonomy of the sub-systems involved has become a characteristic feature of national innovation policy as well as a major challenge (Grande and Peschke, 1999). In the

EU, this ‘linkage problem’ has an additional dimension since innovation policy is not only confronted with the issue of establishing channels of communication for cooperation among the actors and organizations relevant in science & technology policy, but in addition, the different national research systems and the various levels of policymaking have to be linked and integrated as well (Grande and Peschke, 1999).

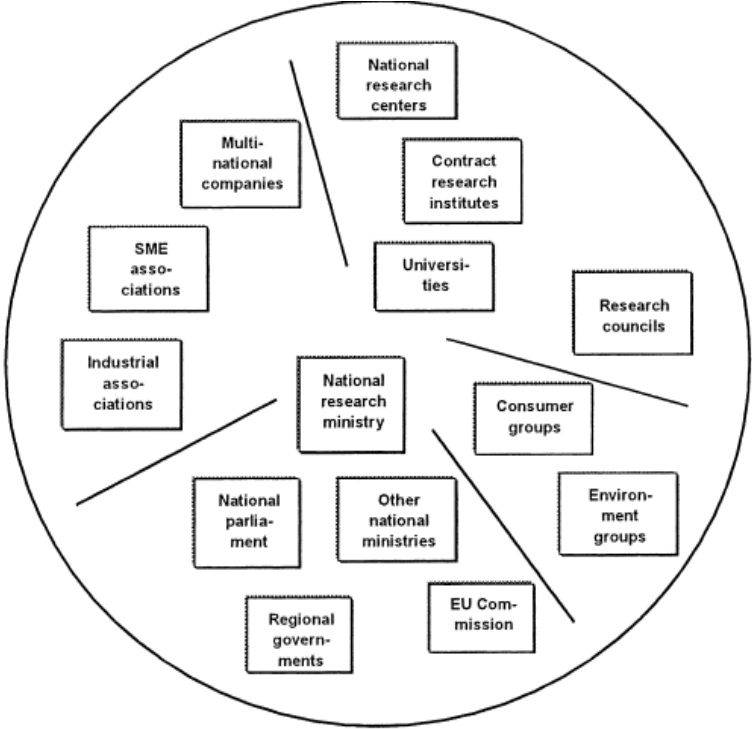


Figure 2: Innovation policy arena
Source: in (Kuhlmann, 2001)

So far, policy coordination at the EU and national level has been addressed through the 'open method of coordination' and the use of voluntary guidelines and recommendations (European Commission, 2007). Despite these transnational efforts, evidence of a ‘governance gap’ reflected in the high degree of fragmentation, stratification and duplication of innovation policies in Europe still exists (Kuhlmann and Edler, 2003). The majority of public initiatives is still mainly developed in national policy arenas addressed to national beneficiaries, in the implicit assumption that the research institutes, universities and enterprises involved carry out their innovation activities entirely or for the most part within national boundaries (Kuhlmann, 2001). There is a role for the political system to intervene in regional and national innovation systems but there is also an emerging consensus that the idea of a European level of innovation policy needs to be developed (European Commission, 2002). Diversity is a European asset, but a lack of transparency, bad coordination, and

duplication means a waste of resources: innovation policy in Europe needs structure, adaptation, coordination and mediation (European_Commission, 2002).

3.2. Mapping of European innovation policies main challenges and priorities

Different countries reveal different approaches towards science and technology policy design and implementation in response to specific challenges inherent to their national innovation systems and, in essence, as a result of their history, culture and political contexts (Lemola, 2002). In the last decade, most OECD countries have been confronted with a new set of challenges to improve the efficiency of public research and to facilitate the translation of research into commercial realities (OECD, 2004). These challenges have been described, in a broadly categorisation, as belonging to two types: pressures for science systems to respond better to a more diverse set of stakeholders and the need to adapt to changes in the processes of knowledge creation and transfer (OECD, 2004).

At European level, policy challenges are identified on the basis of several elements, with emphasis being put in the EU-27 country reports and the latest comparative results provided by the European Innovation Scoreboard (EIS), which provides a comparative assessment of the innovation performance of EU Member States (European_Commission(a), 2008). Responses to these challenges affect the decision making processes that determine the setting of research priorities, the allocation of funds to the public and private research sectors and the management of research institutions (OECD, 2004). The following analysis on the challenges and priorities of European innovation policies has been based on the 2008 European Innovation Progress Report (EIPR),⁴ which provides a synthesis of the work undertaken by the network of national innovation correspondents that draft the INNO-Policy TrendChart country reports. Each year the national correspondents are asked to identify the key challenges facing innovation policies in their country.

From the perspective of a typology of failures in innovation systems (market; capabilities; institutional; network; framework and policy failures), cf. Table 3, the identified challenges have been classified in the 2008 EIPR and their relative weighting is summarised in Figure 5.

⁴ The EIPR analysis is based on the count of the number of innovation measures introduced in INNO-Policy Trendchart. Due account should be taken to the fact that advanced countries tend to introduce a smaller number of larger, more complex support measures addressing diverse groups of stakeholders, which may be reflected in the results obtained, European_Commission(a). (2008) European Innovation Progress Report 2008. In Inno Policy Trendchart: Enterprise Directorate-General.

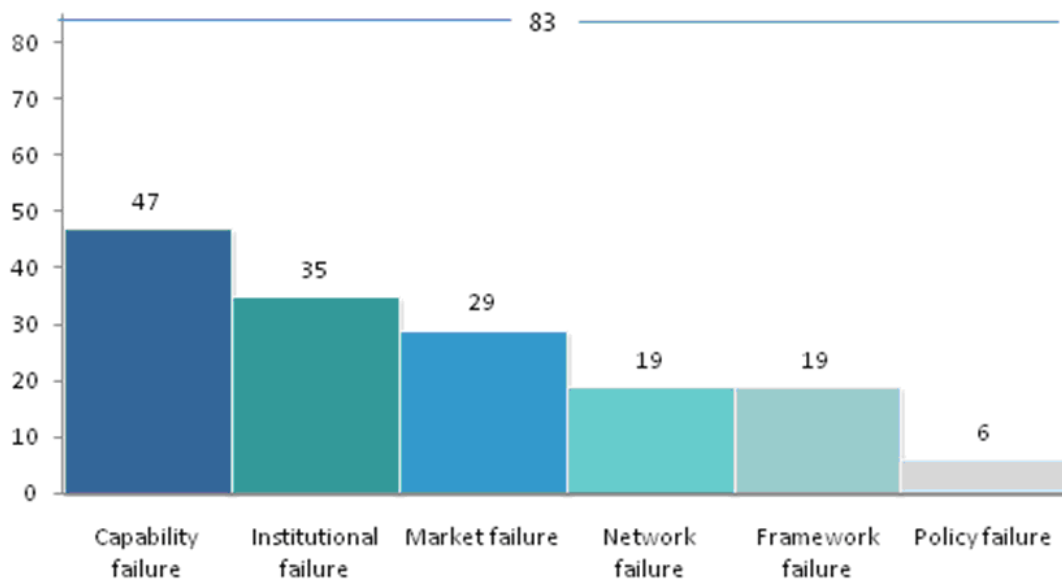


Figure 3: Failures targeted by EU-27 innovation policy challenges

Note: The numbers over the vertical bars indicate the number of challenges addressing one or more failures. There were 83 challenges defined in the 2008 TrendChart country reports.

Source: in (European_Commission(a), 2008)

Capabilities failures, translated into managerial deficits, weak know-how on technological or organisational innovation, have been reported as the most predominant failure, ahead of market and institutional failures, suggesting that more attention should be given in policy support to alleviate internal factors hindering innovation from European enterprises (European_Commission(a), 2008). Network failures, as for industry science cooperation and clustering, often considered a weakness of many national innovation systems, was less relevant as a challenge than market, institutional and capabilities failures (European_Commission(a), 2008).

Concerning the policy mix and the extent to which it targets a particular failure (see Figure 6), the moderate innovators⁵ and catching-up countries give much more emphasis to “capability failures”, in the form of direct support to companies, while the more advanced countries pay more attention to network failures, reflecting a shift to a broader understanding of innovation drivers in their economies (European_Commission(a), 2008).

⁵ According to the European Innovation Scoreboard (EIS) countries are ranked into 4 categories based on their innovation performance across 29 indicators (the Summary Innovation Index – SII): innovation leaders and followers if they rank above the EU-27 SII scores and moderate innovators and catching-up countries if they rank below. More information about the EIS and SII may be found in <http://www.proinno-europe.eu>.

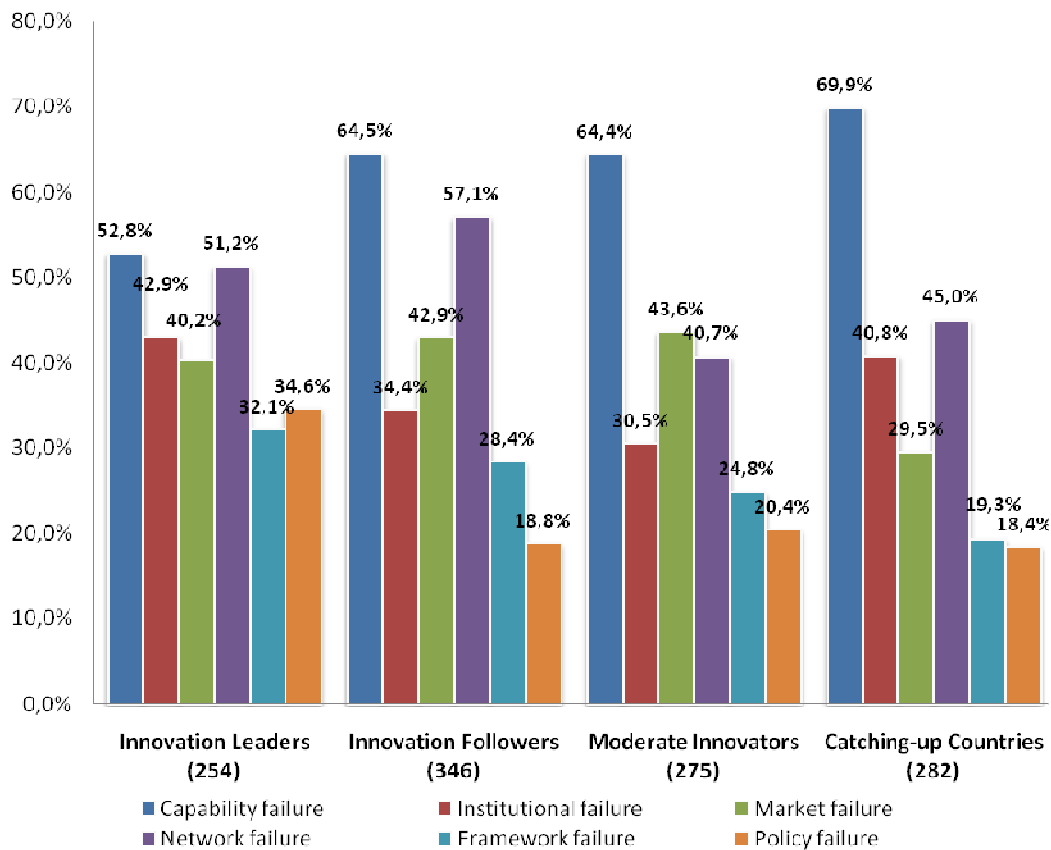


Figure 4: Differences in failures addressed by EIS country group.

Note: The percentages refer to the share of measures in of EIS country group addressing a given failure. Measures can target more than one type of failure. The numbers in brackets indicate a total number of support measures in EIS groups (N=1157).

Source: Adapted from (European_Commission(a), 2008).

Regarding the priorities most often addressed by EU-27 innovation policies, “support for R&D cooperation”, including joint research projects run by public-private consortia of business and research, ranks first (Figure 7) with nearly one-third of all support measures reporting R&D cooperation as one of their key priorities (European_Commission(a), 2008). Changing innovation processes and trends in the division of labour between the private and public sectors may partly justify the need for strong industry-science linkages (OECD, 2004). Such linkages serve both to facilitate industry’s uptake and commercialisation of public-sector research results and to ensure that research performed in the public sector is adjusted to social and economic problems (OECD, 2004).

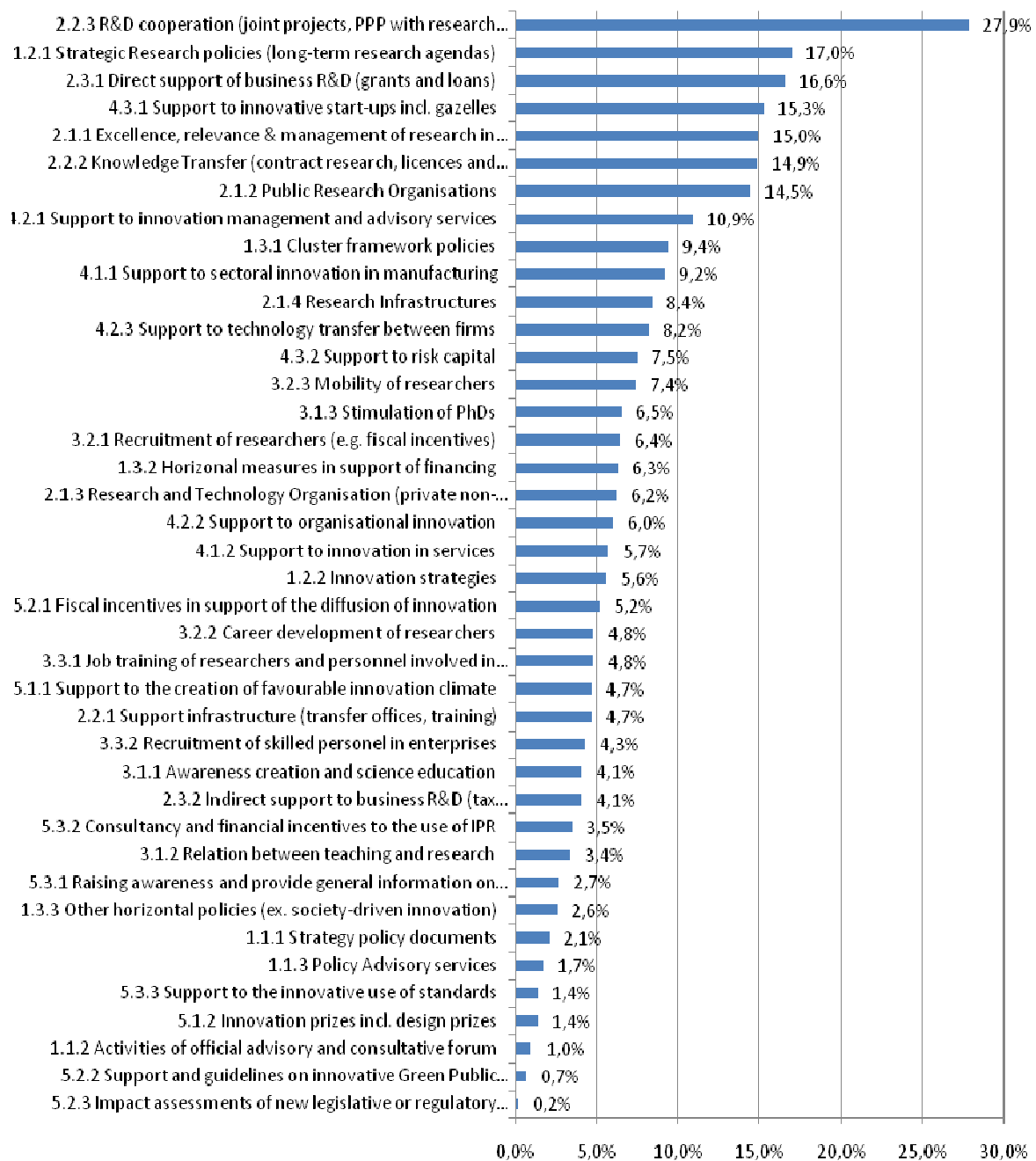


Figure 5: Policy priorities in the EU-27 innovation policy mix

Note: Percentages refer to the share of measures addressing a given policy priority in the overall EU innovation policy mix (N=1157). A single support measure can be assigned up to four policy priorities

Source: Adapted from (European_Commission(a), 2008)

The following most often addressed priorities include implementing strategic research policies such as long-term research agendas (17% of support measures), direct support for business R&D (17%), support to innovative start-ups (15%), measures targeting excellence and management of research in universities (15%) and knowledge transfer, covering contract research, licensing and IPR issues, (15%) (European_Commission(a), 2008). Bottom line is the “impact assessment of new legislative or regulatory proposals” with only 0.2% of

measures from EU-27 member states directed to tackle this priority (European_Commission(a), 2008).

Surprisingly, measures addressing human capital are relatively under-represented in the overall policy mix, notably in what concerns mobility of researchers (7%), recruitment of researchers (6%) and skilled personnel in enterprises (4%), job training of researchers and other personnel involved in innovation process (5%), career development of researchers (5%) as well as, more generally, stimulation of PhDs (6%) (European_Commission(a), 2008). Qualified and mobile human resources are the foundation of all scientific and technological accomplishments in the public and private sectors, both factors are seen as an important aspect of efforts to diffuse scientific and technological knowledge (OECD, 2004). As stressed in OECD study on Science and Innovation Policy Key Challenges and Opportunities (2004: 14), “policy makers are looking into a variety of measures to help increase graduation rates, mobility and the relevance of educational programmes”. Hence, although recognised as a need for policy intervention, still, comparatively to other priorities, not enough attention is being given by the EU-27 to the implementation of specific measures addressing human resources for science, technology and innovation. The EC has been an active proponent in setting programmes to promote the mobility of researchers on a pan European scale compensating for the incentive shortage at national level (Siegel et al., 2007). Examples of such initiatives are the Framework Programme Marie Curie Mobility Grants and, more recently, the Marie Curie Industry-Academia Partnerships and Pathways (IAPP) to foster exchange of know-how and experience through one-way or two-way secondments between the private and public sector.

Also elucidative is the analysis of the evolution of policy priorities over time represented in Figure 8. From mid-1990s until mid-2008 shifts in the innovation policy agenda demonstrate an increasing number of measures supporting science-industry links, at the beginning of the 2000s, and measures targeting start-ups from 2006 onwards (European_Commission(a), 2008). The accentuated increase in the number of innovation policy measures from 2004 onwards is clearly due to measures introduced in the new Member States, mostly co-financed by the Structural Funds (European_Commission(a), 2008).

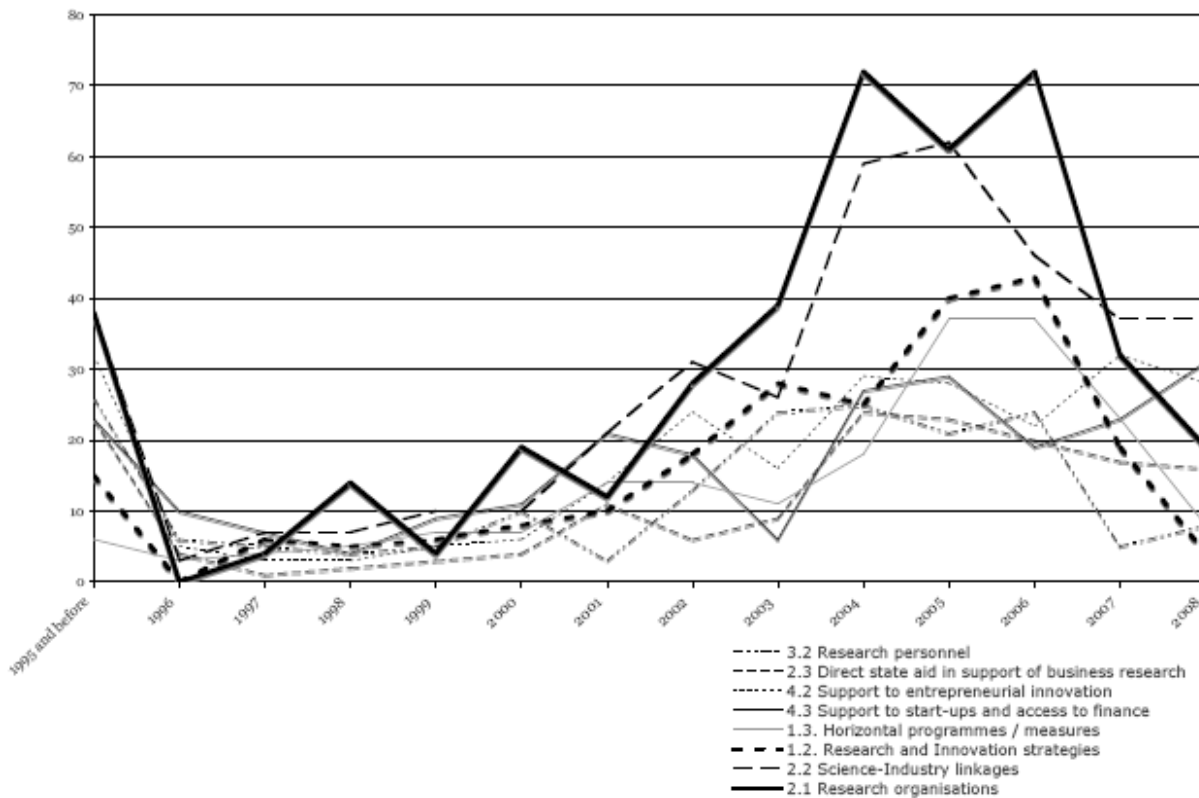


Figure 6: Evolution of the priorities of innovation policies

Note: The absolute values on the vertical axis represent a number of new measures addressing a policy priority introduced in a year. The exhibit presents the priorities with 150 and more measures currently reported as web-published or draft in the support measure database. The chart does not account for an accumulation of measures in time.

Source: in (European_Commission(a), 2008)

Innovation policies are concerned above all with companies, nearly 65% of measures, and research performers with more than 42% of all support measures (European_Commission(a), 2008). Notably, in last couple of years, a higher importance has been given to support measures targeted at improving the diffusion of technologies in enterprises and innovation management and commercialisation of innovation (including IPR) (European_Commission(a), 2008), which may be interpreted as a higher concern for technology transfer issues in the innovation policy agenda of most European countries.

3.3. Innovation policy and technology transfer

The environment in which technology transfer takes place plays a key role in defining the best approaches and, ultimately, their success. The ability to innovate depends not only on the organisation innate conditions but also on its context: including “framework conditions” and governance mechanisms which surround it (Falk, 2007), considered by some to be the most important external factors stimulating universities to engage in technology transfer and establish TTOs (European_Commission(b), 2004). In fact, the form of incentives for public research organisations to engage in technology transfer affects not only the likelihood and

efficiency of technology transfers but also its orientation and the channels used for this purpose.(European_Commission(b), 2004). For instance, the public funding of incubator facilities in a science park may help to established several companies in the surroundings of the university stimulating collaboration links, employment opportunities for alumni and knowledge transfer. In the same way governments may take the lead in promoting venture capital and proof of concept incentives which may very well be decisive to un-shelve technologies that otherwise could not be further developed.

Diffusion-oriented policies have been in place in some countries for several years reflecting a growing consciousness that knowledge transfer must improve in order to accelerate the exploitation of research and the development of new products and services (European_Commission, 2001; Georghiou, 1997; Siegel et al., 2007). An increasing goal of the EU innovation policy has been to enhance the effectiveness and coherence of existing innovation and technology transfer instruments and policies, and to disseminate knowledge concerning innovation processes (European_Commission, 2002). The question of stimulating technology transfer has been also stressed in various discussions at European Council level. As an illustration, in the conclusion of the Competitiveness Council of September 2004⁶ it is stated that: "The Council of the European Union highlights the need to pay special attention to actions in the following areas: (...) promoting favourable conditions for technology transfer and innovation, especially, taking into account the needs of SMEs, noting in this context the important of intellectual property rights."

The shift to more collaborative forms of innovation has stimulated the expansion of markets for technology through which technologies are licensed or shared (OECD, 2004). Nowadays, virtually all regions in Europe provide some sort of support, direct or indirect, for technology transfer activities, either for Technology Transfer Offices, spinouts or licensing (European_Commission, 2002). Whereas support was originally often indirect and targeted at the development of economic growth and the creation of jobs through start-ups, more and more regions are now implementing programmes that directly support technology transfer (European_Commission, 2002). Among the direct policy measures to foster technology transfer and links between science and industry, the following measures are well-established practices in almost all countries (European_Commission, 2001): (1) specific financial support for collaborative research, mostly provided within thematic programmes or for special groups

⁶ Council of the European Union, Competitiveness (Internal Market, Industry and Research), Council Conclusions, Brussels, 24 September 2004, 12487/2004. TTA Final report.

of enterprises (SMEs), based on the assumption that direct collaboration between industry and science researchers is the most effective way to transfer knowledge and exchange competence; (2) specific financial and informative support to SMEs, directed towards improving innovation management capabilities, enlarging R&D and innovation financing, and direct grants for stepping into collaborative research relationships, contract research, personnel mobility, training and consulting services; and (3) researchers mobility from science to industry, including subsidies to enterprises (typically small enterprises) for covering labour costs when employing young researchers, scholarships for PhD students for carrying out a PhD at an enterprise, exchange programmes for mutual visits and temporary placements.

Having a dominating SME structure of the enterprise sector, Austria is one of the countries that most actively has been working in the implementation of measure to support collaborative R&D efforts targeted to SMEs (European_Commission, 2001). The policy measure "Innovation Voucher" (AT 159),⁷ an incentive for Austrian SME to cooperate with knowledge institutes for the first time, illustrates this trend. Austrian SME can obtain a 5,000€ Innovation Voucher through a simple application procedure and spend it in a contract with a public R&D institution or a university that do e.g. studies, feasibility analysis, concepts for technology transfer or innovation projects etc. In Denmark, a new programme named "open" funds (DK 34),⁸ has also been established to strengthen the research and innovation cooperation between SMEs and the research and academic community. "Open" funds will be awarded to projects that do not fall under the category of already known forms of cooperation. Public financing reduces barriers to entry for such collaborations, such as uncertainty of outcome, information asymmetries, and the problem of individually appropriating the results of joint research efforts (European_Commission, 2001).

To stimulate the mobility of researcher and stop the "brain drain", Belgium implemented the Brussels-Capital - Brains (back) to Brussels (BE 184) with the aim to invite high-level scientists to come to or return to the academic research in Brussels. The research projects that receive financial support need to contribute to the development of the Region. Portugal implemented the "Doctoral Grants in Companies" measure (PT 72),⁹ aimed at attracting doctoral students to focusing their dissertation on issues relevant for firms, and to undertake

⁷ In <http://www.proinno-europe.eu/index.cfm?fuseaction=wjw.measures&page=list&CAT=39&CO=1>), accessed 26th June 2009.

⁸ In <http://www.proinno-europe.eu/index.cfm?fuseaction=wjw.measures&page=list&CO=3>, accessed 26th June 2009.

⁹ In <http://www.proinno-europe.eu/index.cfm?fuseaction=wjw.measures&page=list&CO=15>, accessed 26th June 2009.

them in a firm context and, in this sense, encouraging a strategy of cooperation between companies and Universities.

Industry representatives often mention the lack of transfer capabilities in public science (with respect to both individual researchers and the organisation) as a major barrier to interaction, therefore, policy attempted to overcome this bottleneck by employing a variety of measures, including the establishment of technology transfer offices to reduce transaction costs, eliminate information asymmetries and increase professionalism in transfer activities (European Commission, 2001). This concern is reflected in policies such as the Hungarian “INNOTETT” (HU 110),¹⁰ to develop the services of technology transfer centres, business incubation, connecting R&D performing organisations and firms utilising their results and to strengthen their market oriented attitude, and Switzerland policy “KTT - knowledge and technology transfer” (CH 20)¹¹ to implement five consortiums consisting of KTT service centres to link TTOs at universities, and the federal institutes of technology on a regional level and promote "good practices" in technology transfer to the private sector. Nowadays, most universities run their own technology transfer/liaison offices, or have access to consulting networks that support scientists in patenting and licensing activities (European Commission, 2001).

The promotion of start-ups from science is currently also a well-established element of innovation policy in Europe, with almost all countries introducing new supportive measures, many of them based upon regional approaches, combining infrastructure (incubators), consulting and pre-seed financial support (European Commission, 2001). The UK High Technology Fund (UK 54),¹² is a "fund of funds", it commenced in 2000 and has raised €152 million in funds, to invest in venture capital funds targeting the early stage high technology SME sector. With similar intentions, Finland implemented the Funding Scheme for Young Innovative Companies (FI 36),¹³ to increase the number and to accelerate the development of enterprises which are willing to grow fast and to get international.

There are also a number of policy initiatives in the field of strengthening the use of IPR in public science, including financial support, expert advice, and administrative support (European Commission, 2001). Solid examples of some of those policies are the GAPI -

¹⁰ In <http://www.proinno-europe.eu/index.cfm?fuseaction=wiw.measures&page=list&CO=20>, accessed 27th June 2009.

¹¹ In <http://www.proinno-europe.eu/index.cfm?fuseaction=wiw.measures&page=list&CO=45>, accessed 27th June 2009.

¹² In <http://www.proinno-europe.eu/index.cfm?fuseaction=wiw.measures&page=list&CO=18>, accessed 26th June 2009

¹³ In <http://www.proinno-europe.eu/index.cfm?fuseaction=wiw.measures&page=list&CO=4>, accessed 26th June 2009.

Industrial Property Support Offices (PT 26),¹⁴ financing small units specialised on the provision of information and on the development of actions concerning the promotion of industrial property and the creation, in Denmark, of Patent Information Centres and Thematic Information Centres (DE 7)¹⁵ to provide access to scientific and technological information that is contained within patents, registered designs and trade marks for firms and private inventors.

4. Conclusions

Discussions about technology transfer often lead to a quest for assessing the efficiency of the technology transfer process and for comparisons between organisations and countries (Chapple et al., 2005; Siegel et al., 2007; Thursby and Kemp, 2000). It is very difficult to describe the technology transfer process adequately and to monitor it with simple indicators. As mentioned earlier, research in technology transfer still remains an incipient and rather opaque universe, there are few standard definitions, and little data is collected in a systematic way. Nevertheless, indicators interpreted in context can lead to an informed discussion aimed at improving knowledge about technology transfer efficiency. Understanding the determinants that affect university technology transfer may furthermore lead to changes in university policies and organizational practices and public policy conducive to an increased technology transfer efficiency (Friedman and Silberman, 2003).

Framework conditions, and notably public innovation policies, have been referred as an important determinant for technology transfer efficiency (European_Commission(b), 2004; Falk, 2007; Friedman and Silberman, 2003; Goldfarb and Henrekson, 2003). Although, these policies have been in place in some countries for several years (European_Commission, 2001; Georghiou, 1997; Siegel et al., 2007), little work as been done to estimate their impact, at least in what concerns technology transfer.

The present study provided a comprehensive appraisal of the determinant of technology transfer, focusing on innovation policies for technology transfer enhancement.

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¹⁴ In <http://www.proinno-europe.eu/index.cfm?fuseaction=wiw.measures&page=list&CO=15>, accessed 26th June 2009

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