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POLICY APPROACHES REGARDING TECHNOLOGY TRANSFER: PORTUGAL AND SWITZERLAND COMPARED

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Policy approaches regarding technology transfer: Portugal and Switzerland compared

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Abstract

The environment in which technology transfer takes place plays a key role in defining the best approaches and, ultimately, their success. In the present paper we analyse the extent to which Technology Transfer Offices (TTOs) efficiency is influenced by framework conditions and, in particular, by the innovation policies and programmes. We hypothesise that countries with higher technology transfer efficiency levels would have innovation policies more supportive to technology transfer efforts. Results based on an in depth account and statistical analysis of over 60 innovation policies from Switzerland (widely associated to high levels of technology transference efficiency) and Portugal (a laggard country in this particular) corraborate our initial hypothesis. Switzerland policies overall include more references to knowledge and technology transfer, in the form of licenses, R&D collaboration and spin-offs, than Portuguese policies. One exception is the case of patents (intellectual property rights, in general) with stronger weight in Portuguese policies and, to some extent, the support to spin-off creation and venture capital. The findings highlighted significant differences in variables with impact in technology transfer, namely the priorities addressed, target groups and funding eligibility, aspects of the innovation process targeted and forms of funding. From the exercise it was possible to derive some policy implications. Specifically, we advance that if a country wishes to increase technology transfer efficiency then it should implement a mandate for R&D cooperation between different actors, give priority to fund cutting edge science and research performers, and attribute a higher emphasis on applied industrial research and prototype creation aspects of the innovation process.

Keywords: Technology transfer, innovation policies, technology transfer efficiency

1. Introduction

Recent studies on industry science links suggest a tendency to the intensification of the interactions between universities and industry over time (Debackere and Veugelers, 2005). Due to the increasing budgetary stringency of public funding, universities and other public research institutions are increasingly expected to transfer more efficiently and at a higher speed the know–how they generate into commercial activities (Debackere and Veugelers, 2005), through patenting, licensing, research joint ventures and the formation of spin-off companies (Link et al., 2003). Technology licensing has become a very lucrative and prominent business for some universities in the USA and around the world (Anderson et al., 2007; Link et al., 2003). Not only is it a source of revenue to the university but it develops university-industry relations that benefit both parties, promotes economic development, and brings additional research grants to the university (Trune and Goslin, 1998).

According to the Association of Technology Transfer Management (AUTM),[1] before 1980, fewer than 250 patents were issued to U.S. universities each year and discoveries were seldom commercialized for the public's benefit. In contrast, in fiscal year 2002, AUTM members reported that 5.327 new license agreements were signed and between 1991 and 2004, annual invention disclosures increased more than 290 percent (to 18.178), new patents filed increased nearly 450 percent (to 11.089) and new licenses and options executed increased about 510 percent (to 5.329). This has led to a change in the institutional environment and set the ground for the development of public policies specially aimed at encouraging the commercialisation of inventions and the creation of intermediary structures such as the Technology Transfer Offices (TTOs) (Debackere and Veugelers, 2005; Link et al., 2003; Siegel et al., 2003).

The surge of new technology transfer institutions in the last 25 years, mainly in the USA but also in Europe, was deeply connected with the growing awareness of the relevance of intellectual property rights (European_Commission(a), 2004; Swamidass and Vulasa, 2008). While in 1980, the number of research universities in North America with a licensing or technology transfer office was roughly of 20, in 1990 it increased to 200 and by 2000 nearly every major university had one (Colyvas et al., 2002). Although several authors (European_Commission(a), 2004; Siegel et al., 2003; Swamidass and Vulasa, 2008; Trune and Goslin, 1998) had attributed the rise of university patenting and the aftermath rising of TTOs fundamentally to the University and Small Business Patent Procedures Act of 1980, otherwise known as the Bayh-Dole Act, Colyvas et al (2002) are inclined to justify this trend with the rising and maturing of new scientific disciplines, in the decade of 70, such as

[1] In: http://www.autm.net/AM/Template.cfm?Section=FAQs#4, accessed 4 April, 2009.

molecular biology, genetic engineering, computing sciences and biotechnology, all of which rose interest from industry (Colyvas et al., 2002). Regardless of the different opinions, in the USA the Bayh-Dole Act instituted a uniform patent policy, removing many restrictions on licensing, and, most importantly, the ownership of patents arising from federal research grants shifted from federal government to the universities, given them empowerment to proceed with its commercialisation (Debackere and Veugelers, 2005; Link et al., 2003; Siegel et al., 2003; Trune and Goslin, 1998). At the same time various Patent Office and Court decisions increased the range of research that could be patentable as for biotechnology (Colyvas et al., 2002). Other factors, such as the rise in venture capital, important breakthroughs in computing and, more recently, nanotechnology, besides genetic engineering, and the increase in the pool and mobility of scientists and engineers have also contributed to the inclusion of an economic mandate in universities in addition to their mission of education and research (Rothaermel et al., 2007).

There is, however, a strong suggestion of an inadequate scale and intensity of those transfers, in particular in Europe, also known as the "European Paradox", attributed to the gap between top scientific performance and their minimal contribution to industry competitiveness (Debackere and Veugelers, 2005). Some European universities are rich sources of technology[2] but they lag behind in terms of efficiency in technology transfer when compared with their U.S counterparts, largely due to different legal systems (Rothaermel et al., 2007), significant dispersion of resources and activities, insufficient links with business and society, and rigidities in their functioning (European_Commission, 2007). Still, patenting remains excessively complicated and costly in Europe, and fragmented litigation fails to provide sufficient legal certainty (European_Commission, 2007). Furthermore, considerable diversity exists in technology transfer procedures and policies as well as the organisation of TTOs developed in response to specific legislation and market opportunities (Bercowitz et al., 2001).

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

[2] According to data from the ERA Green paper on the European Research Area, universities and public research organisations perform more than 35% of all research undertaken in Europe. European_Commission. (2007) GREEN PAPER - The European Research Area: New Perspectives, Brussels, COM(2007) 161 final.

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 SMEs,[3] or to provide a particular service such as patenting support (European_Commission(b), 2004).

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) (cf. Figure 1). Mainstream literature aggregates technology transfer determinants in two major categories: 1) 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); 2) 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).

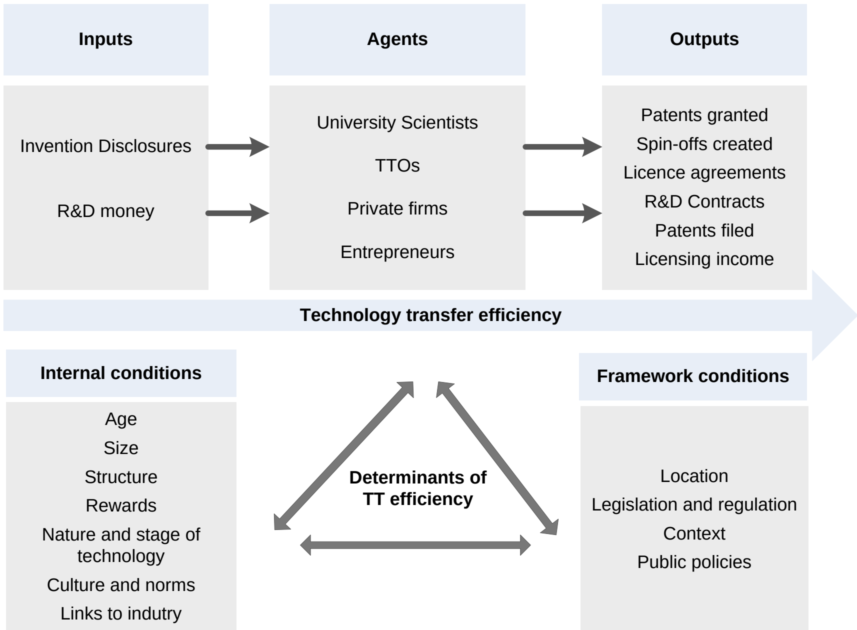


Figure 1: Technology transfer efficiency
Source: The authors

[3] SMEs stands for Small Medium Size Enterprises.

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). To our knowledge, there is no published work benchmarking the impact of innovation policies from different countries in relation to technology transfer efficiency.

In the present study our aim is to understand how TTOs efficiency is influenced by framework conditions and, in particular, by the innovation policies and programmes set in two quite different countries in this regard: Switzerland, widely associated to high levels of technology transference efficiency, and Portugal, a laggard country in this particular. We hypothesise that countries with higher technology transfer efficiency levels, translated into outputs generated by a TTO as intermediary agent, would have innovation policies more supportive to technology transfer efforts, in other words, their innovation policies are key to technology transfer efficiency.

Our objective is not to evaluate the efficiency of different national innovation policies but instead to understand to what degree policies are influencing technology transfer and what type of policies would need to be developed to meet the challenges and the need to increase the efficiency of TTOs. With this objective in mind the paper is structured as follows: in the following section, a review of international literature on the topic of innovation policies and technology transfer efficiency and the role of technology transfer offices is presented.. In Section 3, we present the methodology used to select the countries to compare and analyze innovation policies. The subsequent section presents data and results. Finally, concluding remarks close the work.

2. Innovation policies and technology transfer efficiency: a review

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.[4] 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, however they cannot by itself explain divergences in TTO performance (Siegel et al., 2007).

[4] For a more comprehensive explanation of the determinants of TTOs' efficiency see Oliveira and Teixeira (2009).

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). Of particular relevance for the present work are the "policy-related framework conditions" that 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).

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 2004[5] 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 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

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

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 measures to support collaborative R&D efforts targeted to SMEs (European_Commission, 2001). The policy measure "Innovation Voucher" (AT 159),[6] 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),[7] 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),[8] aimed at attracting doctoral students to focusing their dissertation on issues relevant for firms, and to undertake 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),[9] to develop the services of technology transfer centres, business

[6] In http://www.proinno-europe.eu/index.cfm?fuseaction=wiw.measures&page=list&CAT=39&CO=1), accessed 26th June 2009.
[7] In http://www.proinno-europe.eu/index.cfm?fuseaction=wiw.measures&page=list&CO=3, accessed 26th June 2009.
[8] In http://www.proinno-europe.eu/index.cfm?fuseaction=wiw.measures&page=list&CO=15, accessed 26th June 2009.
[9] In http://www.proinno-europe.eu/index.cfm?fuseaction=wiw.measures&page=list&CO=20, accessed 27th June 2009.

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)[10] 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),[11] 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),[12] 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 - Industrial Property Support Offices (PT 26),[13] 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)[14] to provide access to scientific and technological information that is contained within patents, registered designs and trade marks for firms and private inventors.

3. Innovation policies and technology transfer efficiency: methodological underpins

The empirical analysis for the selection of the countries to compare in terms of TTO efficiency is based in information contained in the CEMI Survey of University Technology Transfer Offices in Europe. This survey targeted TTOs of 355 universities, located in Western European countries, whose researchers published more than 200 scientific articles, according

[10] In http://www.proinno-europe.eu/index.cfm?fuseaction=wiw.measures&page=list&CO=45, accessed 27th June 2009.
[11] In http://www.proinno-europe.eu/index.cfm?fuseaction=wiw.measures&page=list&CO=18, accessed 26th June 2009
[12] In http://www.proinno-europe.eu/index.cfm?fuseaction=wiw.measures&page=list&CO=4, accessed 26th June 2009.
[13] In http://www.proinno-europe.eu/index.cfm?fuseaction=wiw.measures&page=list&CO=15, accessed 26th June 2009
[14] In http://www.proinno-europe.eu/index.cfm?fuseaction=wiw.measures&page=list&CO=3, accessed 26th June 2009

to information collected from the ISI Web of Science, in the period 2004-2006 (Conti and Gaule, 2008). A response rate of 59.4% (211 responses) was obtained, with answers coming from 15 countries, considered by the authors to be broadly representative of the target population in terms of size and geography (Conti and Gaule, 2008).[15]

The metrics used in the survey to access success in technology transfer, represented in Table 1, included: license income; number of licenses/options executed; industry sponsored research contract income; number of industry sponsored research contracts; number of patents awarded; number of start-ups established (Conti and Gaule, 2008). These findings are consistent with the ones referred in the work of Siegel et al. (2003), based on interviews to 15 TTO directors/administrators in which licences, royalties, patents, sponsored research agreements and start-up companies where ranked higher as the main outputs of university/industry technology transfer (Siegel et al., 2003).

Table 1: Technology transfer metrics of success used in CEMI survey

	Extremely important	Very important	Important	Somewhat important	Not important
License income	17,56	20,00	**33,17**	14,15	15,12
Number of licenses/options executed	15,12	10,73	27,32	**30,73**	17,07
Industry sponsored research contract income	**28,29**	**28,29**	22,93	6,83	13,17
Number of industry sponsored research contracts	18,54	**29,76**	27,80	7,80	16,10
Number of patents awarded	14,63	22,93	**35,61**	14,15	14,15
Number of start-ups established	12,68	**32,20**	27,32	10,24	7,80

Note: Respondents were asked to rank the importance of each metric. Values represent percentage of answers to each metric. Most frequent answers in bold; n=205.
Source: In (Conti and Gaule, 2008)

For the selected metrics, Switzerland ranked consistently among the top four countries, being the first in terms of the greatest number of licenses executed (followed Belgium, Denmark and the UK); the country that earns the most from licenses (other countries that reported above average results include Belgium, Denmark, the UK, and the Netherlands), the forth in terms of the greatest number of start-ups created (Sweden ranks first followed by the Netherlands and Finland) and the third in the number of industry sponsored research contracts (surpassed only by Danish and Spanish TTOs) (Conti and Gaule, 2008). On the other extreme we have Portugal, a country that in recent years has been strongly committed, both at political and institutional level, to increase technology transfer efforts from public research to industry, visible in the implementation of TTOs in almost all universities as well as in the creation of

[15] The response rate was higher than average for small countries such as Switzerland, Denmark, Belgium, Norway, Finland, Portugal and Ireland Conti, A., and Gaule, P. (2008) The CEMI Survey of University Technology Transfer Offices in Europe. In CEMI Report: École Polytechnique Fédérale de Lausanne: College of Management of Technology. We have taken this response rate into account in the selection of the countries to compare.

public incentives for technology transfer, but still with very scarce results. In the CEMI survey Portugal is among the countries with the lowest results in terms of licensing number and licensing income as well as industry sponsored research contracts (Conti and Gaule, 2008). An exception was the number of start-ups created in which Portugal borderlines the average of respondents (Conti and Gaule, 2008). Additionally, in terms of average staffing levels Switzerland TTOs relate closely to the Portuguese ones, ranging from 6 to 8 full time equivalents employees, and were established in approximate periods of time, with the majority of Switzerland TTOs being established between 1998 and 2002 and Portuguese TTOs in the period ranging from 2003 to 2007.

For the above mentioned reasons we elect Switzerland and Portugal as the countries to compare innovation policies in order to determine their potential influence in technology transfer efficiency at the level of technology transfer offices.

Innovation policies were gathered from the European Inventory of Research and Innovation Policy Measures (EIRIPM) which was created by the European Commission with the aim of facilitating access to information on research and innovation policies and measures within Europe and beyond.[16] This joint inventory brings together national-level information on research and innovation policies, measures and programmes collected and presented by both INNO-Policy TrendChart and ERAWATCH.[17] It aims to ensure a high degree complementarity between the two policy monitoring platforms in order to harmonise the collection and presentation of information and also a practical division of responsibility to avoid unnecessary duplication of effort.[18]

This information is collected and classified into five main sections according to specific policy priorities (see Table 2).[19]

Section 1 "Governance and horizontal research and innovation policies" refers to information pertaining to governance and horizontal policies affecting both research and innovation policy developments, for example as embodied in official government policy documents, and to funding for horizontal support measures; Section 2 "Research and technologies" deals with information covering core R&D policies and related measures aimed at both science and industry and at the interlinkages between them; Section 3 "Human resources" (education and skills) refers to all policies addressing the adequate supply, development and mobility of human resources for research and innovation; Section 4 "Enterprises" is centred on innovation

[16] In http://cordis.europa.eu/erawatch/index.cfm?fuseaction=about.collaboration, accessed 10th April 2009.
[17] In http://cordis.europa.eu/erawatch/index.cfm?fuseaction=about.collaboration, accessed 10th April 2009.
[18] In http://cordis.europa.eu/erawatch/index.cfm?fuseaction=about.collaboration, accessed 10th April 2009.
[19] In http://cordis.europa.eu/erawatch/index.cfm?fuseaction=about.home, accessed 11th April 2009.

Table 2: Policy framework for the European Inventory on research and innovation policies measures

Number and title of innovation policy	Specific objective addressed	Incidence	
		PT	CH
1. Governance & horizontal research and innovation policies			
1.1. Support to policy making (policy intelligence)	1.1.1 Strategy policy documents (official documents, policy consultation papers, green or with papers, Operational Programmes of Structural Funds)	0	0
	1.1.2 Activities of official advisory and consultative forum	0	0
	1.1.3 Policy Advisory services (technology foresight, scoreboard type activities, cluster mapping, sectoral studies of innovation)	0	0
1.2 Research and Innovation Strategies	1.2.1 Strategic Research policies (long-term research agendas)	1	6
	1.2.2 Innovation strategies	1	1
1.3 Horizontal programmes/measures	1.3.1 Cluster framework policies	0	2
	1.3.2 Horizontal measures in support of financing	3	2
	1.3.3 Other horizontal policies (ex. Society-driven innovation)	2	0
2. Research and Technologies			
2.1. Research organisations	2.1.1 Policy measures concerning excellence, relevance and management of research in Universities	0	12
	2.1.2 Public Research Organisations	0	5
	2.1.3 Research and Technology Organisation (private non-profit)	0	0
	2.1.4 Research Infrastructures	0	5
2.2 Science-Industry linkages	2.2.1 Support infrastructure (transfer offices, training of support staff)	1	2
	2.2.2 Knowledge Transfer (contract research, licences, research and IPR issues in public/academic/non-profit institutes)	1	5
	2.2.3 R&D cooperation (joint projects, PPP with research institutes)	5	23
2.3 State aid measures in support of business R&D	2.3.1 Direct support of business R&D (grants and loans)	3	1
	2.3.2 Indirect support to business R&D (tax incentives and guarantees)	1	0
3. Human Resources (education and skills)			
3.1. S&T education	3.1.1 Awareness creation and science education	0	2
	3.1.2 Relation between teaching and research	0	2
	3.1.3 Stimulation of PhDs	1	7
3.2 Research personnel	3.2.1 Recruitment of researchers (e.g. fiscal incentives)	2	1
	3.2.2 Career development (e.g. long term contracts for university researchers)	0	0
	3.2.3 Mobility of researchers (e.g. brain-gain, transferability of rights)	2	1
3.3 Skills development and recruitment	3.3.1 Job training (LLL) of researchers and other personnel involved in innovation	5	4
	3.3.2 Recruitment of skilled personnel in enterprises	4	0
4. Promote and sustain the creation and growth of innovative enterprises			
4.1. Support to sectoral innovation programmes	4.1.1 Support to sectoral innovation in manufacturing	4	4
	4.1.2 Support to innovation in services	4	1
4.2 Support to entrepreneurial innovation	4.2.1 Support to innovation management and advisory services	7	9
	4.2.2 Support to organisational innovation incl. e-business, new forms of work organisations, etc	8	0
	4.2.3 Support to technology transfer between firms	0	4
4.3 Support to start ups and access to finance	4.3.1 Support to innovative start-ups incl. gazelles	8	6
	4.3.2 Support to risk capital	7	1
5. Markets and innovation culture			
5.1. Measures in support of innovation culture	5.1.1 Support to the creation of favourable innovation climate (ex. Roadshows, awareness campaigns)	2	1
	5.1.2 Innovation prizes incl. design prizes	0	0
5.2 Support to the creation of new markets	5.2.1 Fiscal incentives in support of the diffusion of innovative technologies, products and services	1	3
	5.2.2 Support and guidelines on innovative Green Public Procurement (GPP)	0	0
	5.2.3 Impact assessments (on research and innovation issues) of new legislative or regulatory proposals in any policy field	0	0
5.3 Intellectual property protection and standards	5.3.1 Measures to raise awareness and provide general information on IPR	2	0
	5.3.2 Consultancy and financial incentives to the use of IPR	2	0
	5.3.3 Support to the innovative use of standards	0	0

Note: According to data downloaded from the EIRIPM inventory on the 10th of April 2009. A single support measure can be assigned up to four policy priorities and entrepreneurial activity in the private sector, including support to innovation management, non-technological innovation and access to risk and venture capital; Section 5 "Markets and innovation culture" refers to information on policy initiatives to foster and support innovation culture and the market for innovation including the stimulation of new markets, the diffusion of new technologies, enhancement of intellectual property protection and standards and impact assessments of new legislative or regulatory proposals on innovation. Table 2 also illustrates the policy breakdown by priority for Portugal and Switzerland.

To our knowledge, the EIRIPM is the most comprehensive database of innovation policies in Europe and, as such, a natural choice to access information for innovation policy analysis. The empirical analysis presented in the next section is based on data downloaded from the database of innovation policy measures included in the EIRIPM from March until May 2009. A total of 61 innovation policy measures - of which 27 belonging to Portugal (PT) and 34 to Switzerland (CH) - were analysed and scrutinized translating the qualitative information listed in the EIRIPM into an usable database which permitted the statistical analyses performed (using SPSS 17). For Portugal it was originally considered 29 policy measures but we realized that some policies were repeated, as for the case of PT70 NEOTEC and PT69 NEST, so these were excluded from analysis. In order to verify the statistical significance of the differences between the policies measures adopted in Portugal and Switzerland we resort to the non parametric test of Kruskal Wallis.[20] The p-value associated to this test indicates whether we can reject the null hypothesis (of equal population medians). More specifically if p-value is not higher than 10%, we can reject the null hypothesis of equal population means and so to conclude that differences exist between Portuguese and Switzerland policies for the given variable/item.

The EIRIPM inventory was not specifically designed to assess policy elements that might impact on technology transfer efficiency. Using the inventory for this purpose required a categorization of individual variables from the policies into the inventory in order to select which ones could be created for the purpose of assessing policy impact in technology transfer. The variable selection

[20] Parametric tests are either based on a normal distribution or on, e.g., t,t or $\chi 2$ distributions, which are related to and can be derived from normal-theory-based procedures. That is, the parametric tests require that a sample/group analyzed is taken from a population that meets the normality assumption. Non-parametric tests are used when assumptions required by the parametric counterpart tests are not met or are questionable. The Kruskal-Wallis test is the non-parametric analog of a one-way ANOVA. The Kruskal-Wallis test is used to compare independent samples, and tests the hypothesis that several populations have the same continuous distribution, at least as far as their medians are concerned. The use of nonparametric tests is often required when one of the three following cases arises: 1) Small sample sizes; 2) The variables collected are not continuous in nature; 3) The requirements of traditional methods, such as the assumption of normally distributed data, are not satisfied.

was constrained by the categories included in the policy description, explicitly: keywords; policy overview (aims and main goals); background and rationale for creation; policy priorities; research and technology fields addressed; policy tenure and inspiration for its creation; groups targeted and eligibility for funding; forms of funding and sources of co-financing of policies, evaluation practices and findings.

However, defining the adequate variables was not the unique aspect to be accounted for. We had to have sufficient information in the database, for both countries, to be able to construct the adequate typology of the variables. Thus an exploratory overview of the different innovation policies was implemented to determine the depth and extension of the data contained in the policy description. Additionally, we consulted INNO-Policy TrendChart 2008 Policy Trends and Appraisal Reports for both Portugal and Switzerland. There were nevertheless, some questions that have been categorically not filled in. For instance, the questions concerning the contribution of policy to Lisbon objectives and policy budget breakdown. Accordingly, the analysis of innovation policies could not take into account their weight, in line with the importance of their budgets, due to lack of data in the EIRIPM.

4. Innovation Policies and the TTO efficiency: empirical findings from the comparison between Portugal and Switzerland

Technology transfer and policy keywords, aims and rationale

The creation of a policy and associated funding mechanisms is done in response to a specific challenge or failure (European_Commission(a), 2008). By analyzing the keywords, goals and nature of policy and reasoning for its creation in the search of an explicit mention to technology transfer or any of the its dimensions in focus, licensing, industry-university collaboration, patents and spin-offs, we aimed to assess whether they represented a concern or were envisaged as a direct or indirect target of policy intervention.

Our data and analyses show (cf. Table 3), based on the non parametric test of Kruskal Wallis, that statistically significant differences exist between Switzerland and Portugal regarding the variables ‘Policy aims targeting licensing’ (26.5% of policies against 7,4% for Portugal), ‘Policy aims targeting industry-university collaboration’ (35.3% against 7.4% for Portugal), and the variable ‘Reasoning for creation of policy’, where Switzerland reveals a higher concern with licensing activities (23.5% versus 7,4%).

Table 3: Explicit reference to technology transfer (or its dimensions) in the keywords, aims and reasoning for creation of the policies

Groups of variables	Variable	Mean value of the variable analysed		Kruskal-Wallis Test		Statistically significant differences
		PT	CH	Qui-Square	p-value	
Keywords	Refer explicitly to knowledge or technology transfer (1=Yes; 0=No)	33.3	44.1	0.721	0.396	
Aims [refers explicitly to: licenses; industry-university collaboration; patents and spin offs/venture capital (1=Yes; 0=No)]	Licenses	7.4	**26.5**	3.639	0.056	*
	Industry-University collaboration	7.4	**35.3**	6.510	0.011	**
	Patents	7.4	0.0	2.561	0.110	
	Spin offs/venture capital	18.5	29.4	0.947	0.330	
Reasoning for the creation of the policy [refers explicitly to: licenses; industry-university collaboration; patents and spin offs/venture capital (1=Yes; 0=No)]	Licenses	7.4	**23.5**	2.807	0.094	*
	Industry-University collaboration	7.4	17.6	1.362	0.243	
	Patents	3.7	0.0	1.259	0.262	
	Spin offs/venture capital	18.5	23.5	0.222	0.638	

Note: Mean values represented as %; Values in bold signal results with statistical relevance. References were counted as existing or not existing. Frequency of reference was not taken into account. n=61.
Legend: *** (**) [*] statistically significant at 1% (5%) [10%]

Patents, both for the variables of aims (7.4%) and reasoning (3.7%), represent the only dimensions for which Portuguese policies report a higher emphasis than Switzerland (cf. Figure 10), but such 'differences' failed to emerge as statistically relevant.

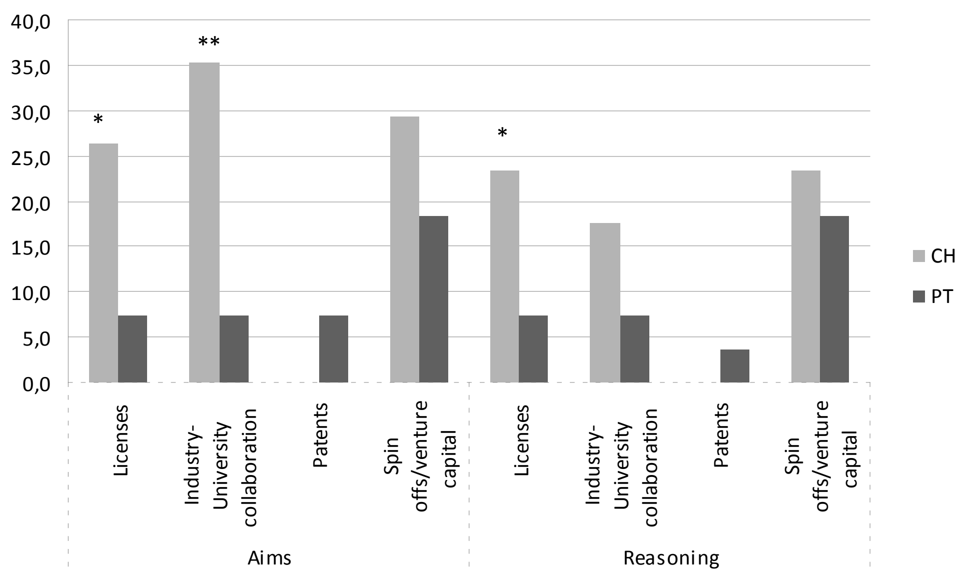


Figure 2: Relative Importance (% total) in each country's aims and reasoning of policy measures of references to licenses, industry-university collaboration, patents, spin-offs and venture capital
Note: In this analysis are included 61 policy measures

As illustrated by Figure 2, the majority of policy measures from Portugal included references to spin-offs and venture capital, although in a still considerably lower extent than Switzerland policies. Industry-university collaboration and licenses represented the dimensions in which higher discrepancies between Switzerland and Portugal could be observed, particularly in the variable “aims”.

Policy priorities

Policy priorities give an overview of the focus and specific objective of each innovation policy. A single policy measure can be assigned up to four priorities reflecting the objectives of policy design and the relative importance each priority represents to the overall policy mix. In Table 4, the list of policy priorities addressed by Portugal and Switzerland policies is presented. The top 3 key policy priorities most often addressed by Portugal were, by decreasing order of importance, ‘4.2.2 Support to organisational innovation’ (29.6%); ‘4.2.1 Support to innovation management and advisory services’ (25.9%) and ‘4.3.1 Support to innovative start-ups incl. gazelles’ (22.2%). As for Switzerland, the top 3 most addressed priorities included ‘2.2.3 R&D cooperation’ (67.6%); ‘2.1.1 Policy measures concerning excellence, relevance and management of research in Universities’ (35.3%), and ‘4.2.1 Support to innovation management and advisory services’ (26.5%).

In what concerns the priority group “Research and Technologies (P_RT)”, statistical significant differences exist between Portugal an Switzerland for priorities: ‘2.1.1: Policy measures concerning excellence, relevance and management of research in Universities’, with 35.3% for Switzerland comparing to 0% for Portugal; ‘2.1.2: Public Research Organisations’, and ‘2.1.4: Research Infrastructures’, both priorities accounting for 14.7% for Switzerland and 0% for Portugal, and ‘2.2.3: R&D cooperation’, in which Switzerland includes 67.6% of its total policy measures against 18.5% in Portugal. Such evidence points to a higher concern in Switzerland compared to Portugal (and even the EU-27 average policy mix) with policy measures targeting research and public universities or research centers. In fact, as we can observe in Figure 3, Switzerland appears highly distanced from the average EU-27 in its concern with R&D cooperation (2.2.3) and policy measures concerning excellence, relevance and management of research in Universities (2.1.1). Policies concerning priorities ‘2.2.1: Support infrastructure’ and ‘2.2.2: Knowledge Transfer’ also show higher values for Switzerland compared to Portugal (5.9% vs. 3.7% and 14.7% vs. 3.7%, respectively), although without statistical relevance.

Table 4: Priorities addressed by policy measures in Portugal and Switzerland

Groups of variables	Variable	Mean value of the variable analyzed		Kruskal-Wallis Test		Statisticall y significant differences
		PT	CH	Qui-Square	p-value	
Priorities - governance & horizontal research and innovation policies (P_GRIP) (1=Yes; 0=No)	1.2.1: Strategic Research policies	3.7	14.7	2.020	0.155	
	1.2.2: Innovation strategies	3.7	2.9	0.027	0.869	
	1.3.1: Cluster framework policies	0.0	5.9	1.615	0.204	
	1.3.2 Horizontal measures in support of financing	1.1	5.9	0.538	0.463	
	1.3.3: Other horizontal policies	7.4	0.0	2.561	0.110	
Priorities - Research and Technologies (P_RT) (1=Yes; 0=No)	2.1.1: Policy measures concerning excellence, relevance and management of research in Universities	0.0	**35.3**	11.669	0.001	***
	2.1.2: Public Research Organisations	0.0	**14.7**	4.254	0.039	**
	2.1.4: Research Infrastructures	0.0	**14.7**	4.254	0.039	**
	2.2.1: Support infrastructure (transfer offices, training of support staff)	3.7	5.9	0.150	0.698	
	2.2.2: Knowledge Transfer (contract research, licenses, research and IPR)	3.7	14.7	2.020	0.155	
	2.2.3: R&D cooperation (joint projects, PPP with research institutes)	18.5	**67.6**	14.388	0.000	***
	2.3.1: Direct support of business R&D (grants and loans)	11.1	2.9	1.612	0.204	
	2.3.2: Indirect support to business R&D (tax incentives and guarantees)	3.7	0.0	1.259	0.262	
Priorities – Human Resources (P_HR) (1=Yes; 0=No)	3.1.1: Awareness creation and science education	0.0	5.9	1.615	0.204	
	3.1.2: Relation between teaching and research	0.0	5.9	1.615	0.204	
	3.1.3: Stimulation of PhDs	3.7	**20.6**	3.703	0.054	*
	3.2.1: Recruitment of researchers	7.4	2.9	0.631	0.427	
	3.2.3 Mobility of researchers (e.g. brain-gain, transferability of rights)	7.4	2.9	0.631	0.427	
	3.3.1 Job training of researchers and other personnel involved in innovation	18.5	11.8	0.537	0.464	
	3.3.2 Recruitment of skilled personnel in enterprises	**14.8**	0.0	5.302	0.021	**
Priorities - Enterprises (P_E) (1=Yes; 0=No)	4.1.1 Support to sectoral innovation in manufacturing	14.8	11.8	0.121	0.728	
	4.1.2 Support to innovation in services	**14.8**	2.9	2.773	0.096	*
	4.2.1 Support to innovation management and advisory services	25.9	26.5	0.002	0.962	
	4.2.2 Support to organisational innovation incl. e-business	**29.6**	0.0	11.405	0.001	***
	4.2.3 Support to technology transfer between firms	0.0	**11.8**	3.344	0.067	*
	4.3.1 Support to innovative start-ups incl. gazelles	22.2	17.6	0.196	0.658	
	4.3.2 Support to risk capital	**18.5**	2.9	4.050	0.044	**
Priorities - markets and innovation culture (P_MIC) (1=Yes; 0=No)	5.1.1 Support to the creation of favourable innovation climate	7.4	2.9	0.631	0.427	
	5.2.1 Fiscal incentives in support of the diffusion of innovative technologies, products and services	3.7	11.8	1.278	0.258	
	5.3.1 Measures to raise awareness and provide general information on IPR	3.7	0.0	1.259	0.262	
	5.3.2 Consultancy and financial incentives to the use of IPR	7.4	0.0	2.561	0.110	

Note: Mean values represented as %; Values in bold signal results with statistical relevance; n=61.
Legend: *** (**) [*] statistically significant at 1% (5%) [10%]

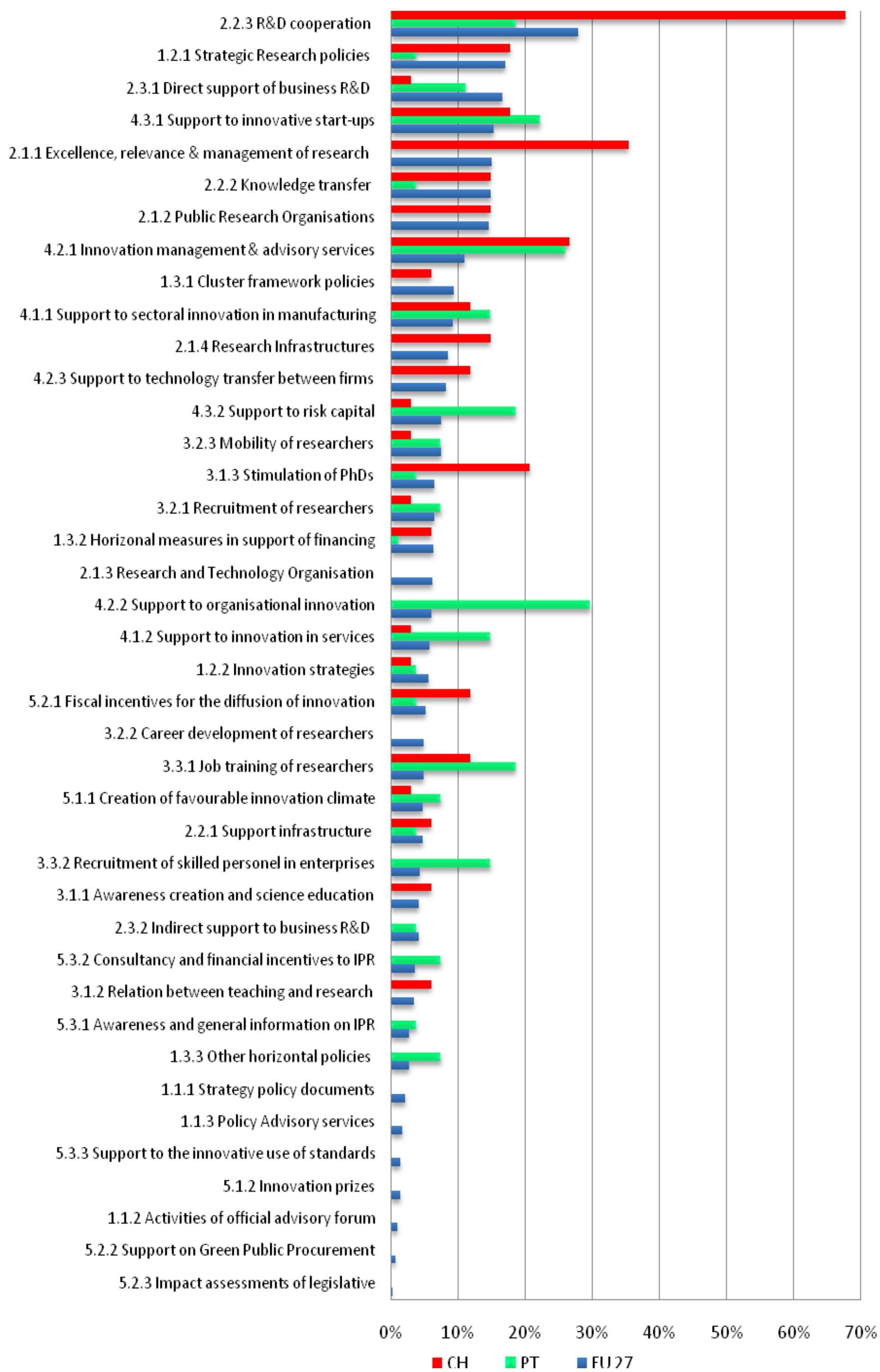


Figure 3: Comparison between policy priorities for Switzerland, Portugal and the EU-27

Note: According to data downloaded from the EIRIPM inventory on the 10th of April 2009. Percentages refer to the share of measures addressing a given policy priority. Data for EU-27 policy priorities taken from the European Innovation Progress report (EIPR) 2008(European_Commission(a), 2008)

Priority group "Human Resources (P_HR), which relates to policies addressing education, skills and mobility of human resources towards research and innovation, reveals significant differences in the priorities '3.1.3: Stimulation of PhDs', with Switzerland leading ahead in terms of policy measures volume (20.6%) and '3.3.2 Recruitment of skilled personnel in enterprises' in which Portuguese policies denote a stronger emphasis (14.8% vs. 0% of Switzerland).

Not surprisingly, Portugal reports more measures than Switzerland to promote and sustain the creation and growth of innovative companies and entrepreneurial activity, included in priority group "Enterprises P_E". In the cases were statistical differences exists Portuguese figures are even higher than that of the EU-27 (cf. Figure 3), namely in what regards to priorities '4.1.2: Support to innovation in services' (14.8%), '4.2.2: Support to organisational innovation' (29.6%) and '4.3.2 Support to risk capital' (18.5%). The relative stronger concern with supporting technology transfer in Switzerland is demonstrated by the statistical relevant differences for priority '4.2.3 Support to technology transfer between firms', with 11.8% against 0% for Portugal.

Thematic focus of the support measures

The majority of Portuguese policies (91.7%) does not have a focus on a specific theme or technological area, as demonstrated in Table 5 and Figure 4.

Table 5: Technology fields addressed by innovation policy

Groups of variables	Variable	Mean value of the variable analysed		Kruskal-Wallis Test		Statistically significant differences
		PT	CH	Qui-Square	p-value	
Targeted research and technology fields	No specific focus	91.7	16.7	9.91	0.020	**
	ICT	0.0	8.3			
	Nanoscience and nanotech	0.0	16.7			
	Biotechnology	0.0	8.3			
	Social economics & humanities	0.0	8.3			
	Health	0.0	16.7			
	Energy	0.0	8.3			
	Food, agriculture and fisheries	8.3	0.0			
	Materials	0.0	8.3			
	Other	0.0	8.3			

Note: Mean values represented as %; n=61
Legend: *** (**) [*] statistically significant at 1% (5%) [10%]

This is consistent with the findings of the EIPR, in which it is reported that only 12% of all EU-27 measures were targeted to support a precise technological field (European_Commission(a), 2008). An exception was the field of "food, agriculture and fisheries", in which Portugal reported one policy (8.3%), to be precise "PT 76: Innovation Support System – Innovation Projects". As for Switzerland the most targeted research areas have been Nanosciences and nanotechnologies (16.7%) and health (16.7%).

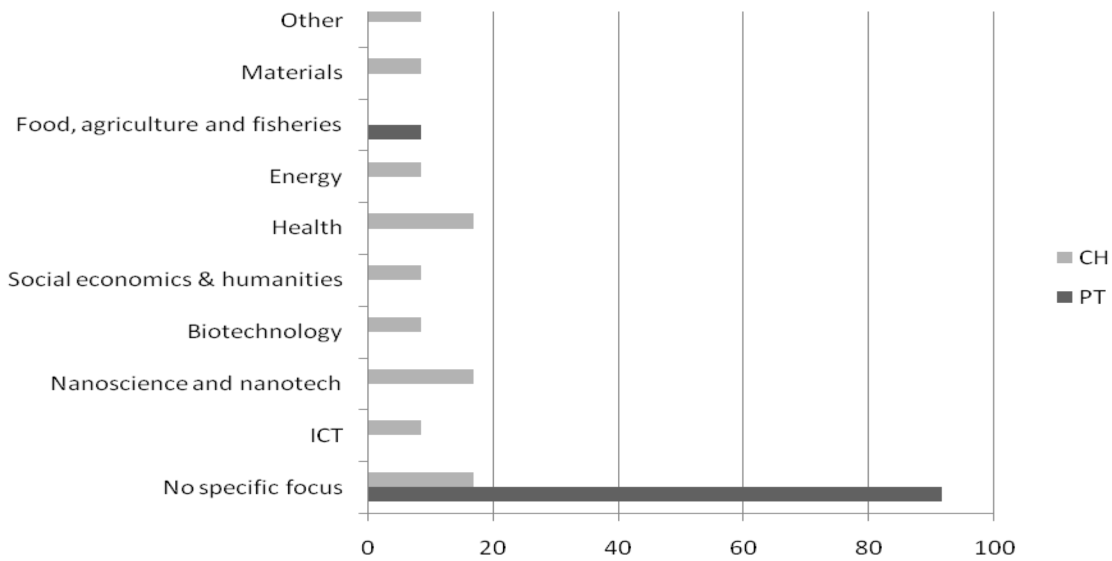


Figure 4: Thematic focus of innovation policies (in % of total)
Note: In this analysis are included 61 policy measures

Policy tenure

Policy tenure reflects the year of creation of a determined innovation policy as well as its longevity in years. Logically, given the time it can take for a specific policy to take effect, a minimum period of implementation time is necessary before deciding to replace or discontinue such policy. Hence, through this variable we aimed to assess the soundness of policies and the stability of the policy making system. As Table 6 exemplifies, Switzerland had an earlier concern with the design and implementation of its policies than Portugal. The majority of Switzerland policies started between the time period ranging from 1995 to 2005 in opposition to Portuguese policies with higher incidence from 2000 to 2009 (see also Figure 5).

Table 6: Average policy tenure

Groups of variables	Variable	Mean value of the variable analysed		Kruskal-Wallis Test		Statistically significant differences
		PT	CH	Qui-Square	p-value	
Policy tenure	Starting year group (1: [1995;1999]; 2: [2000;2004]; 3: [2005; 2009])	2.333	1.910	5.455	0.020	**
	duration (years)	3.963	7.087	14.509	0.000	***

Note: n=61
Legend: *** (**) [*] statistically significant at 1% (5%) [10%]

Additionally, the average duration of Switzerland policies is of 7.1 years against Portuguese policies with roughly 4 years. Due consideration should be taken nevertheless regarding residual policies that remain in the database without indication of its state (active or inactive). Most policies analysed did not stipulate an ending date and in the case they are not regularly updated it may very well impact in policy duration analysis.

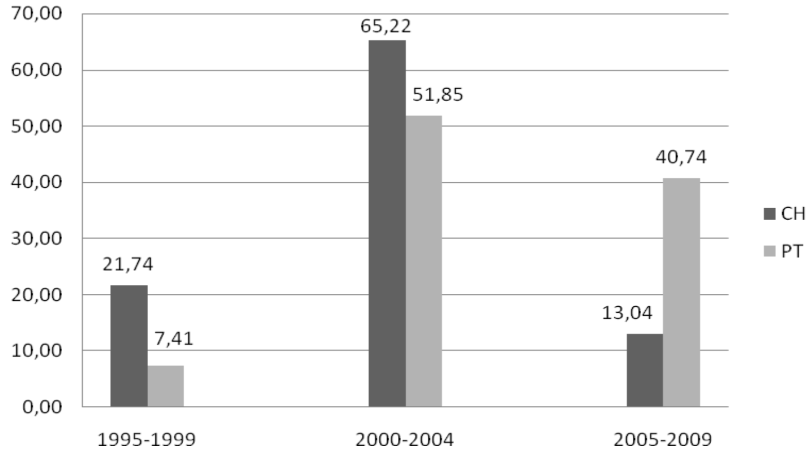


Figure 5: Amount of policy measures (in % of total) by average starting period
Note: In this analysis are included 61 policy measures

Policy creation

Portuguese policies (cf. Table 7 and Figure 6) are inspired mainly by national policy debate (78.3%), followed by the need to meet EU level policy objectives (43.5%) and an existing policy of another EU country (21.7%).

Table 7: Inspiration for policy creation

Groups of variables	Variable	Mean value of the variable analysed		Kruskal-Wallis Test		Statistically significant differences
		PT	CH	Qui-Square	p-value	
Policy creation inspiration	National policy debate	78.3	90.6	1.616	0.204	
	Need to meet EU level policy objectives	**43.5**	3.1	13.372	0.000	***
	Existing measure of another EU country	**21.7**	3.1	4.684	0.030	**
	Other	13.0	18.8	0.313	0.576	

Note: Mean values represented as %; Values in bold signal results with statistical relevance; n=61.
Legend: *** (**) [*] statistically significant at 1% (5%) [10%]

The same tendency is observed for Switzerland policies for which national policy debate represents the main inspiration for policy creation (90.6%). However, significant differences are observed in the variable “need to meet EU level policy objectives” accounting only for 3.1% of Switzerland polices against 43.55% of Portuguese policies and in the variable “existing measure of another EU country" (3.5% for Switzerland in comparison to 21.7% for Portugal). These differences may be explained by the fact that Switzerland does not belong to the European Union not being therefore as much influenced by the EU objectives or other policies developed by EU member states as Portugal.

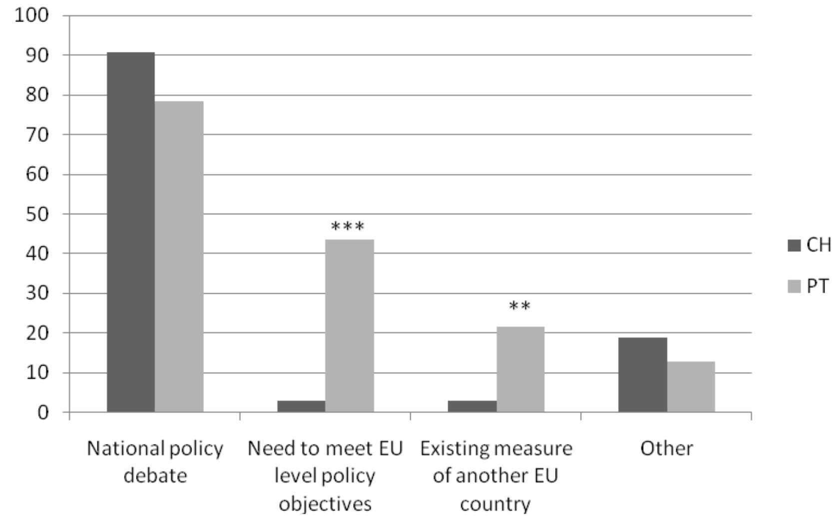


Figure 6: Inspiration for policy creation (in % of total policy measures)
Note: In this analysis are included 61 policy measures
Legend: *** (**) [*] statistically significant at 1% (5%) [10%]

Target groups and eligibility for funding

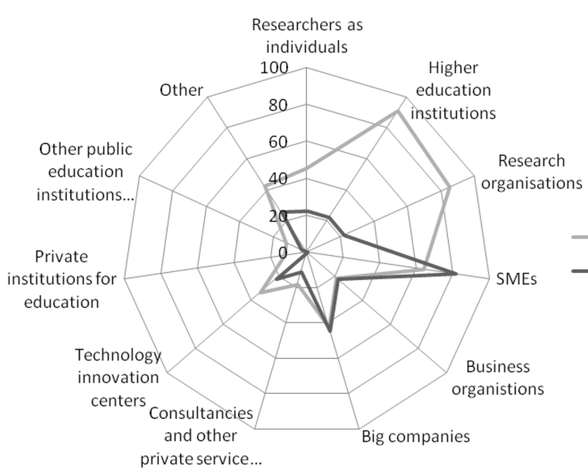
Policies from Portugal are above all concerned with companies and in particular with SMEs (81.5% of the corresponding total). In contrast, as Table 8 describes, Switzerland policies preferably target research performers, with nearly 91% of the total measures focused in higher education institutions, 84.8% in other non-profit research institutions, and 45.5% in individual researchers. On average, only 22.2% of Portuguese innovation policies target research organisations and individual researchers (cf. Figure 7).

The same tendency is shown in the target group "eligibility for funding", with Switzerland focusing their policies incentives mainly on researchers (80%), higher education institutions and research organisations (both with 60%). Portugal funds essentially SMEs, encompassing 68.4% of policies, although in this regard Switzerland follows closely the Portuguese figure with 60% (cf. Figure 7).

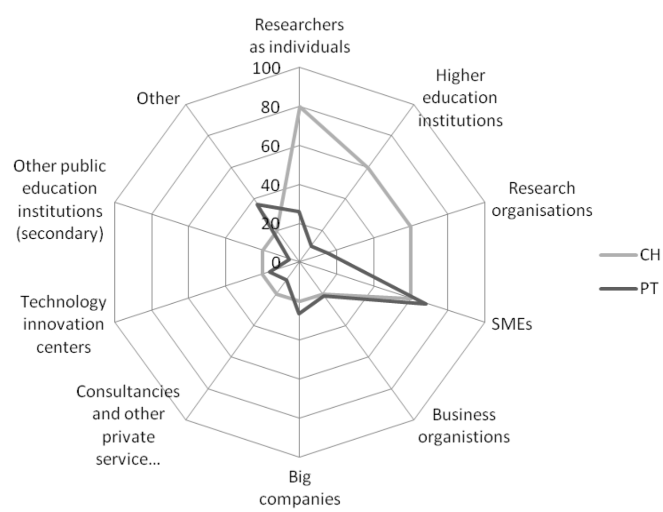
Table 8: Groups targeted by the support measures and their eligibility for funding

Groups of variables	Variable	Mean value of the variable analysed		Kruskal-Wallis Test		Statistically significant differences
		PT	CH	Qui-Square	p-value	
Target groups	Researchers as individuals	22.2	**45.5**	3.464	0.063	*
	Higher education institutions	22.2	**90.9**	28.705	0.000	***
	Research organisations	22.2	**84.8**	23.323	0.000	***
	SMEs	81.5	63.6	2.290	0.130	
	Business organisations	22.2	21.2	0.009	0.925	
	Big companies	44.4	42.4	0.024	0.876	
	Consultancies and other private service providers (non-profit)	11.1	18.2	0.573	0.449	
	Technology innovation centers	22.2	33.3	0.888	0.346	
	Private institutions for education	0.0	**12.1**	3.448	0.063	*
	Other public education institutions (secondary)	3.7	12.1	1.354	0.245	
	Other	25.9	42.4	1.747	0.186	
Eligible for funding	Researchers as individuals	26.3	**80.0**	4.665	0.031	**
	Higher education institutions	10.5	**60.0**	5.630	0.018	**
	Research organisations	15.8	**60.0**	3.954	0.047	**
	SMEs	68.4	60.0	0.121	0.728	
	Business organistions	21.1	20.0	0.003	0.960	
	Technology innovation centers	15.8	20.0	0.048	0.826	
	Big companies	26.3	20.0	0.081	0.776	
	Consultancies and other private service providers (non-profit)	11.1	20.0	0.261	0.610	
	Other public education institutions (secondary)	5.3	20.0	1.078	0.299	
	Other	36.8	20.0	0.484	0.487	

Note: Mean values represented as %; Values in bold signal results with statistical relevance; n=61.
Legend: *** (**) [*] statistically significant at 1% (5%) [10%]



Target groups



Eligibility for funding

Figure 7: Target groups and eligibility for funding of different target groups
Note: In this analysis are included 61 policy measures

Cooperation between actors of the innovation system is highly stressed by Switzerland, with 89.7% of policies reporting collaboration as mandatory for funding eligibility, when more than one target group is identified (see Table 9 and Figure 8). Policies from Portugal either leave cooperation as optional (41.2%) or as not required for funding eligibility (23.5%).

Table 9: Importance of cooperation and networking for eligibility criteria

Groups of variables	Variable	Mean value of the variable analysed		Kruskal-Wallis Test		Statistically significant differences
		PT	CH	Qui-Square	p-value	
	Cooperation for eligibility [0: no; 1: optional; 2: mandatory]	1,118	1,897	15,551	0,000	***

Note: n=61.
Legend: *** (**) [*] statistically significant at 1% (5%) [10%]

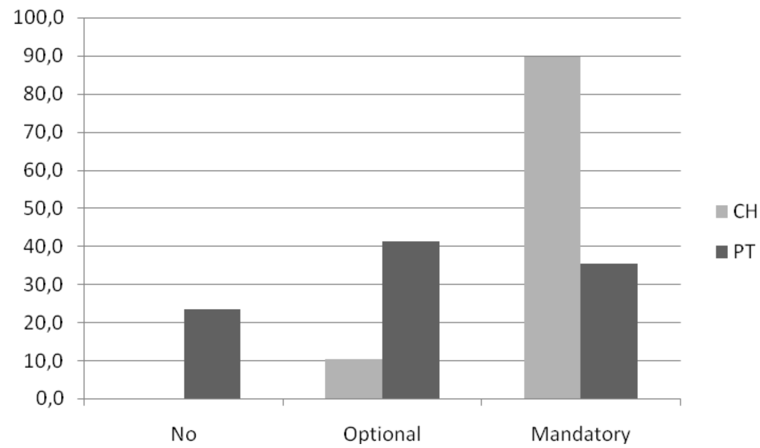


Figure 8: Incidence (in % of total policy measures) of cooperation and networking requisite in innovation policies for funding eligibility
Note: In this analysis are included 61 policy measures

Aspects of innovation process

In respect to the different possible stages of the innovation process our data shows (cf. Table 10) that the aspect most oftently targeted by Switzerland policies included appplied industrial research (52.9%) and prototype development and creation (47.1%). This is consistent with the findings of the EU-27 EIPR (2008) in which prototype creation and applied industrial research were reported as the most addressed stages of the innovation process (European_Commission(a), 2008). As for Portugal, pre-competitive research (34.6%), awareness raising amongst firms on innovation (26.9%) and innovation managment tools (26.9%) were the most envisaged aspects.

The differences were statistically significant (with Switzerland reporting the higher figures) for basic research (20.6%); human research development (35.3%); knowledge transfer between researchers (38.2%); networking (38.2%) and cooperation, promotion and clustering (20.6%). Innovation management tools represented the only variable in which policies from Portugal statistically significantlly surpassed Switzerland policies, involving 26.9% of total (cf. Figure 9). According to the EIPR (2008), innovation management is in fact one of the innovation processes emphasised by moderate innovators, as is the case of Portugal, in the EU-27 countries (European_Commission(a), 2008).

Table 10: Aspects of innovation process targeted by support policies

Groups of variables	Variable	Mean value of the variable analysed		Kruskal-Wallis Test		Statistically significant differences
		PT	CH	Qui-Square	p-value	
Aspects of innovation process	Awareness raising amongst firms on innovation	26.9	35.3	0.469	0.493	
	Prototype creation	7.7	**47.1**	10.691	0.001	***
	Industrial design	15.4	14.7	0.005	0.942	
	Improving legal environment	11.5	8.8	0.119	0.731	
	Entrepreneurship and incubators	19.2	5.9	2.505	0.113	
	Basic research	3.8	**20.6**	3.514	0.061	*
	Problem driven basic	11.5	20.6	0.854	0.355	
	Pre-competitive research	34.6	32.4	0.033	0.855	
	Diffusion of technologies in enterprises	11.5	20.6	0.854	0.355	
	Applied industrial research	23.1	**52.9**	5.384	0.020	**
	Knowledge transfer between researchers	15.4	**38.2**	3.726	0.054	*
	Human research development	0.0	**35.3**	11.279	0.001	***
	International collaboration	15.4	26.5	1.049	0.306	
	Networking	15.4	**38.2**	3.726	0.054	*
	Commercialisation of innovation (IPR)	7.7	**32.4**	5.191	0.023	**
	Social sciences research	0.0	8.8	2.375	0.123	
	Cooperation, promotion and clustering	3.8	**20.6**	3.514	0.061	*
	Innovation management tools	**26.9**	5.9	5.031	0.025	**

Note: Mean values represented as %; Values in bold signal results with statistical relevance; n=61.
Legend: *** (**) [*] statistically significant at 1% (5%) [10%]

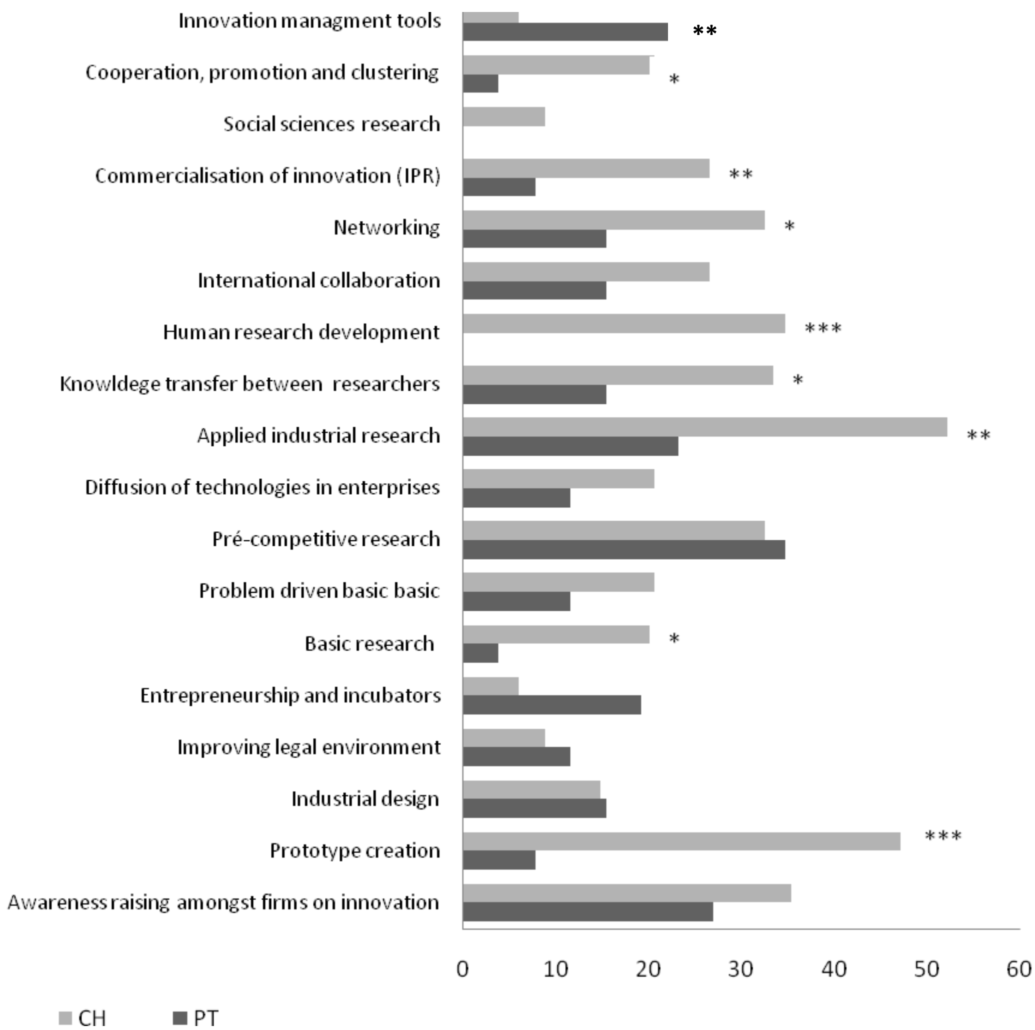


Figure 9: Aspects of innovation process targeted by policies

Note: In this analysis are included 61 policy measures

Legend: *** (**) [*] statistically significant at 1% (5%) [10%]

Typologies of funding and eligible expenses

Direct grants represent the most common form of innovation policies funding, both for Portugal (57.7%) and Switzerland (54.5%) (cf. Table 11).

Statistically relevant differences (Table 11 and Figure 10) exist for indirect funding, mainly in the form of tax incentives, reported as the second most applied typology of funding in Switzerland (42.4% of measures), and subsidized loans with higher incidence in Portugal (15.4%). Such evidence corroborates EIPR (2008), which underlines that subsidised loans have been most often used by moderate innovators while, in the last couple of years there have been relatively less supporting measures introduced using tax incentives (European_Commission(a), 2008).

Table 11: Forms of funding and eligible costs for funding

Groups of variables	Variable	Mean value of the variable analysed		Kruskal-Wallis Test		Statistically significant differences
		PT	CH	Qui-Square	p-value	
Form of funding (when applicable)	Grants	57.7	54.5	0.057	0.811	
	Indirect funding (tax incentives, certification, etc.)	7.7	**42.4**	8.725	0.003	***
	Subsidized loans	**15.4**	3.0	2.813	0.093	*
	Venture capital	15.4	6.1	1.360	0.243	
	Other	23.1	27.3	0.133	0.716	
Eligible costs	Labour	41.7	**83.9**	10.462	0.001	***
	Equipment	37.5	54.8	1.602	0.206	
	Infrastructures	0.0	9.7	2.412	0.120	
	Training	**54.2**	22.6	5.726	0.017	**
	IPR	**25.0**	3.2	5.669	0.017	**
	Technology transfer agreements	**12.5**	0.0	4.024	0.045	**
	External expertise	50.0	38.7	0.688	0.407	
	Other	**66.7**	12.9	16.590	0.000	***

Note: Mean values represented as %; Values in bold signal results with statistical relevance; n=61.
Legend: *** (**) [*] statistically significant at 1% (5%) [10%]

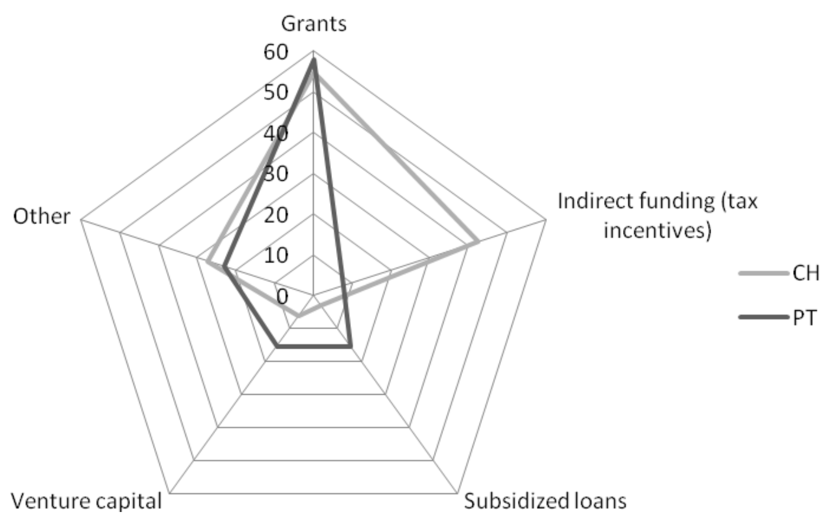


Figure 10: Typologies of funding of innovation policies
Note: In this analysis are included 61 policy measures

Regarding the eligibility of cost (cf. Table 11 and Figure 11), when direct funding is provided, Switzerland policies seem to prefer supporting costs related, essentially, with labour (83.9%) and equipment (54.8%), a trend that is probably connected with the policies' focus in research institutions and individual researchers. On the other side, Portugal elects training (54.2%) and other costs (66.7%) as the most common categories of costs to be supported by policy incentives. Surprisingly, IPR (25.0%) and technology transfer agreements (12.5%) have been reported more than once as eligible typology of costs for Portuguese policies

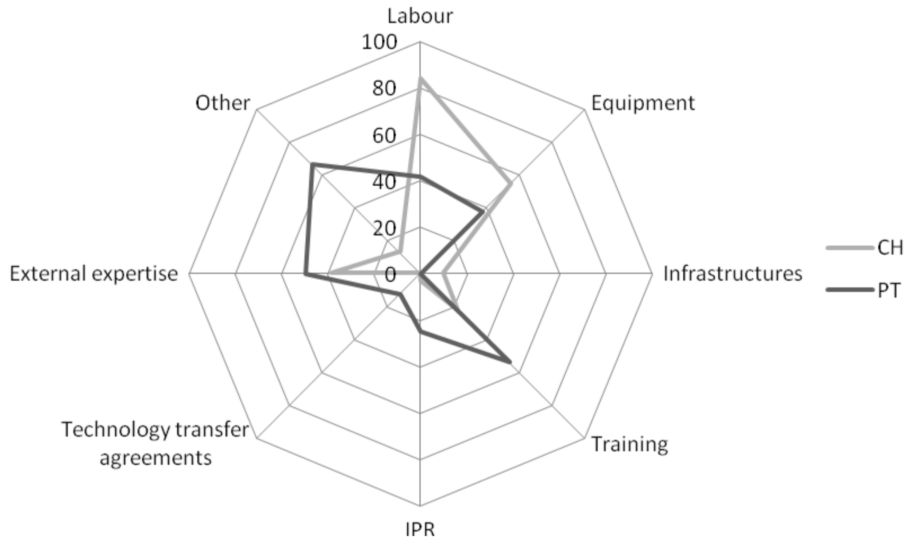


Figure 11: Eligible costs for funding of innovation policies
Note: In this analysis are included 61 policy measures

Funding Sources

Significant differences exist between funding sources of Switzerland and Portuguese policies (cf. Table 12). While Portuguese measures are mostly co-financed by structural funds (78.5%) and marginally by private (13.0%), a mix of both private and structural funds (4.3%) and other forms of funding (4.3%), Switzerland policies are almost totally supported by private funds (see also Figure 12). This is explained by the fact that Switzerland, not being part of the European Union, is not entitled to the Structural Fund Operational Programmes (OPs).

Table 1: Sources of co-financing

Groups of variables	Variable	Mean value of the variable analysed		Kruskal-Wallis Test		Statistically significant differences
		PT	CH	Qui-Square	p-value	
	Financing_sources_3.6 [0: private; 1: structural funds; 2: other; 3: mix]	1.000	0.167	22.833	0.000	***

Note: n=61.
Legend: *** (**) [*] statistically significant at 1% (5%) [10%]

Notwithstanding, the EIPR (2008) also reports that only 4% of all innovation measures in innovation leaders and 12% in innovation followers have been co-financed by Structural Funds, demonstrating that countries with more mature science and technology innovation policies are not so dependent on structural funds (European_Commission(a), 2008).

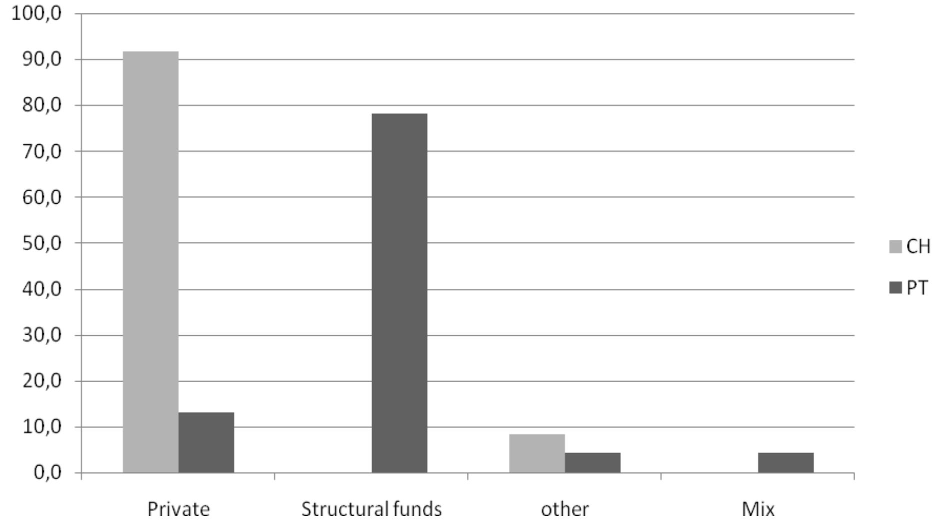


Figure 12: Sources of co-financing of innovation policies

Note: In this analysis are included 61 policy measures

Policy evaluation

Evaluation is crucial to analyse policy performance and formulate policy "best practices". The scope and methods of evaluation differ according to the questions to be addressed and the character of the policy measure, thus, they can be retrospective (ex-post), current or prospective (mid-term and ex-ante), producing information that can be used in the assessment of past policies, the monitoring of ongoing initiatives or the forward planning of innovation policies (Papaconstantinou and Polt, 1997).

Table 2: Evaluation of innovation policies

Groups of variables	Variable	Mean value of the variable analysed		Kruskal-Wallis Test		Statistically significant differences
		PT	CH	Qui-Square	p-value	
Ex-ante Indicators	Using ex-ante indicators	**89.5**	16.7	21.974	0.000	***
Evaluation procedures	Ex-ante evaluation	40.9	22.6	2.012	0.156	
	Mid-term evaluation	31.8	48.4	1.428	0.232	
	Ex-post evaluation	4.5	12.9	1.032	0.310	
Evaluation findings	Description of official evaluation findings [0: negative; 1: too recent; 2: inconclusive; 3: positive]	1.889	2.889	11.447	0.001	***
	Description of unofficial evaluation findings [0: negative; 1: too recent; 2: inconclusive; 3: positive]	1.350	2.346	14.171	0.000	***

Note: Mean values represented as %; Values in bold signal results with statistical relevance; n=61.
Legend: *** (**) [*] statistically significant at 1% (5%) [10%]

In comparing evaluation practices for Portuguese and Switzerland policies, significant distinct results (cf. Table 13) were observed in the use of ex-ante indicators for the measurement of results (89.5% of Portuguese policies in comparison to 16.7% for Switzerland).

The specification of ex-ante indicators seems to have an impact in the afterwards evaluation procedure, since Portugal tend to evaluate most policies ex-ante (40.9%) while Switzerland adopts a preferred mid-term evaluation of policies (48.4%) (cf. Figure 13). Ex-post evaluation is the least used form of evaluation by both countries (4.5% for Portugal and 12.9% for Switzerland), possibly because some policy measures are still in progress and, hence, have not had the opportunity to undergo a final evaluation.

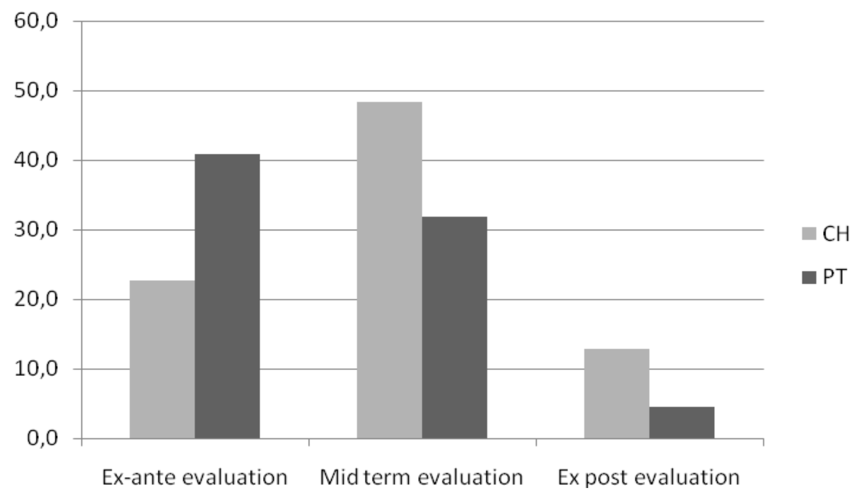
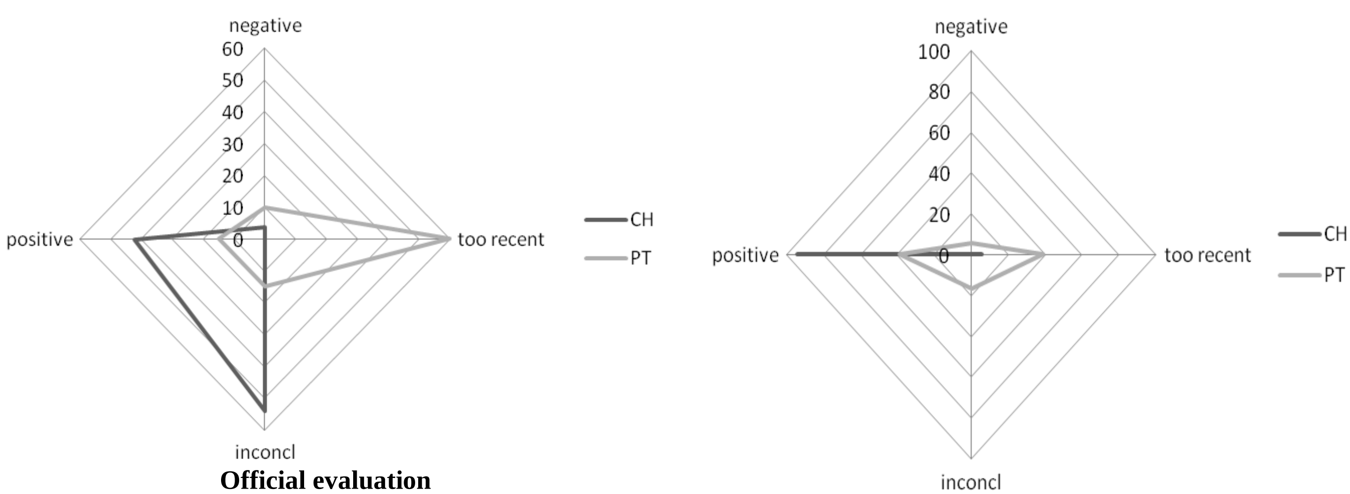


Figure 13: Evaluation procedures for innovation policies
Note: In this analysis are included 61 policy measures



Official evaluation

Unofficial evaluation

Figure 14: Official and unofficial evaluation findings for innovation policies
Note: In this analysis are included 61 policy measures

Statistically significant differences are found both for the results of official and unofficial evaluation of policies (cf. Table 13 and Figure 14). Where an official evaluation has taken place, while most Switzerland policies report inconclusive (53.8%) and positive (42.3%) as the main findings, the majority of Portuguese policies (60%) are included in the "too recent for appraisel of success" category. On the other hand, when no official evaluation has been undertaken, 94.4% of Switzerland policies demonstrate evidence of a positive appraisel of the measure against 38.9% of Portuguese policies.

Policy measures and technology transfer outputs. Are they related?

It is clear from the literature that the context in which technology transfer takes place and, in particular, policy incentives play a key role in motivating universities and public research institutes to engage in technology transfer. The different policies applied by Portugal and Switzerland have had an effect on the technology transfer environment in each country and therefore on the variables identified in this study. Table 14 summarises the key similarities and differences in the results of this study. It is interesting to notice that there are many more differences than similarities listed.

Analysing first the support to technology transfer in keywords, aims and rationale, both Portuguese and Switzerland policies included references to the major technology transfer outputs identified, although to different degrees. It is apparent that Switzerland policies are very much concerned with the collaboration between industry and university and include higher explicit references to licensing activities. Innovation policies such as CH20 – Knowledge and Technology Transfer (KTT), funding the implementation of 5 KTT centers in Switzerland with the aim to reinforce demand of companies for university knowledge and research result, may have contributed to the results observed. Both countries' policies emphasize support to spin-off creation and venture capital funds, notably in the reasoning for policy creation. Portuguese policies are the only ones to refer patents, which may be explained by the consistent low performance of Portugal regarding the 'intellectual property' dimension (EPO and USPTO patents), in the European Innovation Scoreboard, which in turn could have increased the awareness of Portuguese economic agents to the strategic relevance of patenting (European_Commission(b), 2008).

Table 3: Key similarities and differences in policy analysis:

Key variables	Similarities	Differences
Support to technology transfer	▪ References to spin-offs and venture capital in reasoning	▪ Keywords referring to technology transfer higher in CH; ▪ Higher emphasis to licensing in CH policy aims and reasoning* ▪ Industry-University collaboration higher in CH, in aims** and reasoning ▪ References to patents higher in PT
Priorities most addressed	▪ Support to innovation management and advisory services ▪ Support to innovative start-ups	▪ R&D cooperation higher in CH*** ▪ Higher concern with excellence of research in universities in CH*** ▪ Stimulation of PhDs in CH* ▪ Support to public research organisations ** and research infrastructures ** higher in CH ▪ Support to organisational innovation higher in PT*** ▪ Support to risk capital higher in PT **
Thematic focus of the measure addressed		▪ No specific focus for PT policies** ▪ Nanosciences, nanotechnologies and health targeted higher by CH policies**
Policy tenure		▪ CH policies started earlier in time** ▪ CH policies have a higher duration in years***
Main reason for policy creation	▪ National policy debate	
Main target groups		▪ PT targets above all companies ▪ CH targets above all universities***, research organisations *** and individual researchers *
Funding eligibility		▪ PT funds above all SMEs ▪ CH funds above all universities**, research organisations ** and individual researchers**
Importance of cooperation		▪ Cooperation mandatory for funds eligibility in CH***
Aspects of innovation process most addressed	▪ Pre-competitive research	▪ Applied industrial research higher in CH** ▪ Prototype creation higher in CH*** ▪ Innovation management tools higher in PT** ▪ Awareness raising amongst firms on innovation higher in PT ▪ Networking* and knowledge transfer between researchers* higher in CH
Forms of funding	▪ Grants	▪ Tax incentives in CH*** ▪ Subsidized loans in PT*
Most common eligible Costs		▪ Labour *** and equipment in CH ▪ Training ** and other*** in PT
Funding sources		▪ Private for CH*** ▪ Structural funds for PT***
Main evaluation findings		▪ Too recent for PT*** ▪ Positive or inconclusive for CH***

Note: Only the key aspects of policy analysis were included in the Table. Not all similarities are listed and accordingly not all differences, even if statistically relevant are listed.
Legend: *** (**) [*] statistically significant at 1% (5%) [10%]

According to OECD Science, Technology and Industry Outlook 2008, the number of triadic patents per million population [21] in Portugal was 1.07 while in Switzerland it reached 107.56 (OECD, 2008). As a consequence innovation policies specifically targeted at increasing the usage of IPR, such as the GAPI - Industrial Property Support Offices (PT 26) and SIUPI - Industrial Property Use Incentive System (PT 18), have been implemented in Portugal.

Similarities may be found in policy priorities to support innovation management and advisory services as well innovative start-ups. Portuguese policies put higher emphasis on the support given to companies and in creating conditions for the existence of venture capital. This may possibly explain why spin-off creation is the technology transfer output that Portugal ranks better in the CEMI survey (see Section 3). On the other hand, Switzerland policies prioritise research excellence, stimulation of PhDs, R&D cooperation and technology transfer between firms. The importance of R&D cooperation in Switzerland policies is also stressed in the requirements for funds eligibility in which collaboration is mandatory when more than one target group is identified. Joint projects between industry and university are characterised by a critical amount of face-to-face contact, which enables the transfer of the implicit parts of knowledge that are crucial for technology development and creation (European_Commission, 2001). So, the higher the support to R&D collaboration the higher the probability to originate research results with potential to be transferred. Intensive interaction with industry brings also its own benefits such as additional revenues, exchange of experiences, access to laboratories, increased possibilities for students and graduates to find jobs, etc. (European_Commission(b), 2004).

While Portuguese policies tend to be open in terms of technological areas addressed, Switzerland policies focus mainly in emergent technological areas, such as nanotechnologies and health, with potential for commercial application. The broadening of the innovation definition beyond the traditional manufacturing sector is also one direction the Swiss innovation policies are aiming (European_Commission(c), 2008). GSK-initiative (CH 24) can be seen as an example of good practice in Switzerland, since it aims at expanding innovation activities to further industries, more concretely the field of humanities, social sciences and cultural sciences.

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[21] Triadic patents are a set of patents taken at the European Patent Office, the Japan Patent Office and the US Patent and Trademark Office that protect the same invention. The use of triadic patents as an indicator eliminates the problems of home advantage and influence of geographical location that are encountered with single-office patent indicators and thus improves the international comparability of the data OECD. (2008) Science, Technology and Industry Outlook 2008 OCDE.

Policies from both countries also differ in terms of year of implementation and average duration. This variable, altought usefull to determine stability of the policy making system, does not seem to directly affect technology transfer. The same applies for the variable “policy creation” in which both countries report the predominace of national policy debate as main inpiration for policy creation but which, directly, does not impact technology transfer efficiency.

As for the target group addressed by policy measures and eligibility for funding, Portugal concentrates its policies in supporting SMEs, possibly reflecting a need to restructure the industrial fabric, increasing its competiveness and an emergent predisposition to support innovative start-ups [reflected in measures such as NEOTEC Initiative (PT 51); FINICIA-High Innovation Content Projects (PT 56), and NEST New Technology Based Companies (PT 34)]. Switzerland focuses on research performers such as universities, research organisations and researchers [evidence of which may be found in measures such as MedTech - Life Science (CH 5); National Centers of Competence in Research -NCCR (CH 40); NCCR Nanoscale Science (CH 32) and NRP No. 47: "Supramolecular Functional Materials" (CH 37)].

Research is a precondition for technology transfer and thus the volume of research in a country is an indication of the potential for technology transfer. When accessing the number of scientific articles per million population,[22] Portugal counts 251,41 and Switzerland 1.153,54 (OECD, 2008). However, this indicator should be used with caution since a predisposition to publish research may result in less patented technology being available to license or sell to industry (Decter et al., 2007). TTOs are predominantly a department-type organisation (53%) followed by the subsidiary-type (33%) and the independent-type (14%) (European_Investment_Fund, 2005). One may assume that higher flows of funding for the university may also allow a higher budget for TTO operations and staffing with implications at efficiency level. On the other hand, lower incentives for industrial R&D may lead to the need to outsource R&D activities thus increasing the level of contract research and industry-science collaboration.

As for the most often addressed aspects of the innovation process, both countries report a high focus of policies in pre-competitive research, which represent research results that are not immediately marketable even though in a closer stage of originating new products and processes. While Portuguese policies are directed towards factors such as awareness raising amongst firms

[22] Scientific articles per million population is an indicator often used to highlight the scientific “productivity” of countries and is an important measure of research output, since publication is the main means of disseminating and validating research results Ibid.

on innovation and innovation management tools, Switzerland policies are more concerned with developing applied industrial research and prototype creation. One of the most acknowledged obstacles to the technology transfer process has been the existing funding gap to bring technologies to the market (Decter et al., 2007; European_Investment_Fund, 2005) policies that support proof of concept or prototype development should undoubtedly contribute to increase technology transfer efficiency. To reinforce this trend, human research development and commercialisation of IPR were also included amongst the five top aspects of the innovation process targeted by Switzerland policies. The low education level of the labour force is seen as a serious constraint for a stronger bet on knowledge-intensive activities and, as a consequence, technology transfer activities (OECD, 2004).

Grants are the most common form of funding applied by both countries, followed by indirect funding in Switzerland and venture capital in Portugal. Again, it is visible the emphasis set by Portuguese policies in promoting entrepreneurship and the creation of innovative start-ups with the development of the venture capital business, as it is shown by the various measures taken on this regard, including the new legislative framework for the activities of venture capital companies, venture capital funds and venture capital investors (Decree-Law nº 375/2007, of November 8) (European_Commission(b), 2008). Notwithstanding, according to the Innovation Scoreboard for 2008, Portugal still has a relative weakness in the dimension “linkages & entrepreneurship”,[23] with ‘early stage venture capital”, reaching 0.067% of GDP, below EU average (0.107%) and Switzerland (0.141%) (European_Commission, 2009). Eligible costs for funding in Portugal are focused in training and other costs while Switzerland policies refer more often labour and equipment.

Structural funds are the prime source of co-financing innovation policies in Portugal while in Switzerland the private sector takes this role. Increasing the share of private R&D investment is a main target of the EU policy. The "3% initiative" decided at the Barcelona Summit of March 2002, identified the crucial role of R&D and innovation, notably from the private sector, in closing the competitiveness gap between Europe and the US or Japan, and also to keep a competitive edge versus potent newcomers on the global innovation scene, such as China or India (European_Investment_Fund, 2005). Finally policy evalution, official as well as evidence of success from unofficial sources, indicates overall better results for Switzerland policies.

[23] Linkages & entrepreneurship dimension captures entrepreneurial efforts and collaboration efforts among innovating firms and also with the public sector, European_Commission. (2009) European Innovation Scoreboard 2008. Comparative Analysis of Innovation Performance. In ProInno Europe InnoMetrics.

5. 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 contributes with two main elements to the existing literature. First, a comprehensive appraisal of the different dimensions and items included in the innovation policies from technology transfer laggard (Portugal) and frontier (Switzerland) countries, including the corresponding statistical differences. Second, an assessment on how those differences can explain the distinct performance of technology transfer offices in both countries, measured by the produced outputs of licensing, industry university collaboration, patents and spin-off creation.

Results corroborate our initial hypothesis that higher technology transfer efficiency levels are associated to innovation policies more supportive to technology transfer efforts. As expected, Switzerland policies overall include more references to knowledge and technology transfer, in the form of licenses, R&D collaboration and spin-offs, than Portuguese policies. One exception was the case of patents (and intellectual property rights in general) with stronger weight in Portuguese policies and, to some extent, the support to spin-off creation and venture capital. The findings have also highlighted significant differences in variables with impact in technology transfer as for the priorities addressed, target groups and funding eligibility, aspects of the innovation process targeted and forms of funding.

Our aim was not to evaluate the policy quality but rather to understand which policy features would lead to a better performance of TTOs. Given this, and based on our results, we argue that if a country wishes to increase technology transfer efficiency a set of factors should be taken into account in the policy design. Those factors include: a mandate for R&D cooperation between different actors, a priority to fund cutting edge science and research performers and a higher emphasis on applied industrial research and prototype creation aspects of the innovation process.

A final remark, if technology transfer moves up in the political agenda two observations should be kept in mind. First, the establishment of a successful technology transfer office takes time; efficiency will not improve just by changing institutional norms or investing large amounts of funds in the TTO. Second, appropriate policies are supportive, but not of sole relevance. Obviously, other determinants as for internal structures, procedures, priorities, research objectives and the university culture have to be adapted to internalise a real commitment to technology transfer.

The work has two important limitations. First, the work is dependent on the subjectivity of country's respondents when filling up the policy information and the asymmetric availability of information in policies, since not all fields were answered and the same level of detail was not applied to all policies. Second, the limited correspondence we were able to establish between policies and specific technology transfer outputs, apart from the variables keywords, aims and rationale. Although to a limited extent, determinants such as age of TTO and size of staff were controlled, we did not control for other technology transfer determinants and technology transfer inputs, as for size or research endowment of the universities. The extension of the analysis to include innovation policies from other countries with both high and low TTO performance, in order to enlarge the results observed would constitute an interesting path for future research.

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