Intermediary Structures as Part of R&D Policy Efforts to Increase Commercialization and Commodification of Academic Science. The Case of Slovenia.

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Abstract

The contribution deals with the relations between academic science and industry in the context of emerging converging technologies. Attention is focused on the intermediary structures of science as part of an organized policy effort to increase commercialization and commodification of academic science. The situation in Slovenia is presented. In policy terms, the intermediary structures should not only play the role of mechanisms for the transfer of knowledge from academic science to industry, but also stimulate new dynamism for emerging converging technologies. In Slovenia, this progressive function of intermediary structures has not yet been entirely realized.

Introduction

The article presents the theoretical and empirical aspects of increasing commercialization and commodification of academic science. The development of recent academic science is characterized by an orientation towards the innovation-oriented third mission and thus a closer interaction with industry. The importance of this mission will probably continue to grow in the future, as academic science and its practical applications are crucial to the future economic development and welfare of our societies. The development of recent academic science is characterized by a greater proximity to the contexts of its application, by the marked intersection of scientific disciplines, by the heterogeneity of the actors and institutions involved, and by what theoreticians of science term 'reflexivity' and 'social accountability'. Not long ago, the progress of individual scientific disciplines or technologies was sufficient to drive new developmental cycles of individual industrial branches. At present, the development in almost all parts of the economy and society at large depends on the intertwined operations of different types of scientific research. We may refer in this context, for example, to the converging technologies. Converging technologies represent a new phase in the development of science and technology, resulting from the integration and mutual interaction of nanotechnology, biotechnology, information and communication technology (ICT) and the cognitive sciences. Their revolutionary scientific findings are used in the fields of medicine, pharmacy, agriculture, food production, environmental protection and many others.

In this chapter, I am concerned with the relations between academic science and industry, in the context of the emerging converging technologies. Within this extensive and complex theme, I will focus only on some visions. In the first part of my discussion I will reveal the basic changes which are happening in the production of academic scientific knowledge and are the basis for the formation of new, entrepreneurial types of universities. I also present some controversies concerning the recent tremendous increase in different forms of commodification and commercialization of modern academic science. In the second part of my discussion, attention will be focused on the intermediary structures of science as part of an organized policy effort in small transitional countries, such as Slovenia, to interlink academic science and industry. In the conclusion I will briefly consider the centres of excellence, which have been established in Slovenia in the past five years, as these new scientific intermediary structures especially tend to focus on the converging technologies that are expected to bring many economic and societal benefits.

The new social role of academic science in 'Mode 2' knowledge production

The discussions about the new social role of academic science and scientific intermediary structures are connected with the more general and complex relation between science and technology. There exist different theoretical and practical views on this topic. We might say that the predecessor of modern discussions on this issue was the 17th century philosopher Francis Bacon. In his visionary New Atlantis he outlined the kind of modern science which put itself in the role of technological power (Bacon 1926).

Today, the historians and sociologists of science mostly agree that the first industrial revolution did not embody the technical application of science. If we look back in history, it may scarcely be said that science at the time of the first industrial revolution offered very much to technology. The theoretical knowledge was too rudimentary to find its way readily into the solving of technological problems. Watt's improved steam engine, for example, broke all the rules of contemporary physics. Terence Kealey explained it thus:

> The industrial revolution did not represent the application of science to technology, it represented the development of pre-existing technology by hands-on technologies. (Kealey 1996, 72)

The productive links of science and technology did not arise before the end of 19th century. After that period both systems began to strongly interact with each other. Recent times are characterized by the blooming of 'techno-sciences' if we use the term invented by Bruno Latour, the French sociologist of science (Latour 1987). Taking into account the increasing interlinking between science and technology in the 20th century, it comes as a surprise that many social science theorists until recently insisted very strongly on an old-fashioned interpretation of science as a phenomenon which is totally independent from technology. Already before the Second World War, under the influence of controversial discussions about the autonomy and (social) relevance of science, Michael Polany had proclaimed the strict autonomistic idea concerning the republic of science (Polany 1962). According to this view, science was glorified as a strongly autonomous and self-referential social subsystem.

Immediately after the Second World War, the interlinks between science and technology were mostly ignored. The accepted rationale was that there is a relatively clear distinction between basic (science) and applied (technology) research. The former should be the domain of the academic institutions and the latter the domain of the business sector. The main argument of the state was that it would be a mistake to look at the practical orientation of academic science as a guide to where state funding for R&D should be allocated. Vannevar Bush was the key proponent of this type of R&D policy discourse. The title of his report advocating this programme of unrestricted public support of science best caught the spirit of that time: science as an endless frontier (Zachary 1997).

Paradoxically, the concept of clear distinction between science and technology was characteristic of R&D policy in the former East-European communist regimes as well. However, a key principle of the official ideology of the former communist regimes was 'the scientific technological revolution'. Although science and technology were well favoured, little attention was paid to their effective connectedness. Even if basic research in natural and technical disciplines was excellent the links in the innovation chain were broken. Over the past two decades a basic change in the view of key policy actors on the interlinks between science and technology has occurred. Theoreticians and policy makers are increasingly aware that old-fashioned interpretations of science as a strictly autonomous model no longer comply with the reality of the situation. They may possibly have fitted in with the situation fifty years ago. Today we are meeting with increased expectations that scientists will take over the responsibility to create commercially valuable knowledge and contribute to the solving of practical problems in industry. Even academic staff at universities, whose prime mission is to teach, are expected not only to play an active role in the transfer of knowledge to students, but also in the transfer of knowledge to industry. Most of the recent R&D policy models suggest that universities have to move towards an innovation-oriented third mission, and thus a closer interaction with industry. The realization of this new mission is described with different terms, including entrepreneurial university (Clark 1998), enterprise university (Margison & Considine 2000), post-modern university (Rip 2004), and so forth. The contemporary university is a culmination of these new models, where universities need to become more entrepreneurial, act more like enterprises and incorporate the interests of a wide range of stakeholders (Scott 2009). What we are speaking about here is the emergence of the second academic revolution. The first happened in the 19th century with the advent of Humboldt-type universities. At that time the principle of 'the unity of teaching and research' came into force at universities for the first time. At present universities are embarking on a second academic revolution with the introduction of innovative and entrepreneurial functions.

It seems that the concept of 'Mode 2' knowledge production presented in the book *The New Production of Knowledge* (Gibbons et al. 1994) became the symbolic banner of new viewpoints on the social role of academic science in the mid 1990s. In this new approach, the definition and solution of research problems, the so-called context of application, is brought to the fore. This term not only refers to the increased demand for the commercialization of scientific research, but also foresees changes in the cognitive interest of researchers. The researchers in the most progressive scientific fields should not concentrate on researching the fundamental principles of how the world works but rather investigate specifically settled structures within this world.

Let us consider in this context one of the leading scientific and technological fields of the present – converging technology. Converging technologies represent a new phase in the development of science and technology resulting from the integration of nanotechnology, biotechnology, information and communication technology (ICT) and cognitive sciences. They are a (transdisciplinary) research field that is currently undergoing rapid expansion.[1]

The notion of converging technologies could be described as a combination of enabling scientific discoveries (genetics, nanoscience), techniques (informatics, gene splicing) and advances in allied tools (computing power, scanning tunnelling microscopes, robotics) that greatly accelerates the basic science involved and practical applications across a wide range of subjects, from human health to materials science (see for example: Fisher et al. 2006; Whitman 2006).

The case of converging technologies is a paradigmatic case of how the new concept of trans-disciplinarity has put inter-sectoral links to the forefront. This new concept of trans-disciplinarity introduced various actors outside of science as an integral part of the new mode of knowledge production, or, as Michael Guggenheim put it:

> The difference between disciplinary and trans-disciplinary science is not the relevance of research results nor their applicability. The difference is that it is not only scientists who define research questions, theories and methods but also other stakeholders, who introduce other criteria for choosing methods and theories. (Guggenheim 2006, 412)

After the introduction of the concept of trans-disciplinarity in the framework of Mode 2, the category of integration is playing the central role. Thus, as Matthias Bergmann and Engelbert Schramm said:

> Die Frage der Integration ist zentral fuer die Qualitaet trans-disziplinaerer Forschung. Erst Integration auf einer kognitiven, aber auch auf einer sozialen, kommunikativen, einer organisatiorischen und moeglicherweise auch auf einer technischen Ebene fuehrt dazu, dass die transdisziplinaere Forschung gute Ergebnisse zu erzielen vermag. (Bergman & Schram 2008, 10)

Rogers Hollingsworth also says that modern science is in the development phase, which requires the building of a common research core, consisting of shared theoretical frameworks plus a common stock of models and mechanisms that integrates a broad range of domains normally analyzed by different scientific disciplines (Hollingsworth 2006). For example, in an OECD study entitled 'Interdisciplinarity in science and technology', the category of integration is used to differentiate between three types of cross-disciplinary research: (1) multi-disciplinary research is defined as research where the subject under study is approached from different angles using different perspectives, yet integration is not accomplished; (2) interdisciplinary research is defined as research leading to the creation of theoretical, conceptual and methodological identity, i.e. more coherent and integrated results should thereby be obtained; and (3) trans-disciplinary research is defined as research in which a convergence between disciplines is pursued and it is accompanied by the mutual integration of disciplinary epistemologies (OECD 1998).

Is the commodification of academic research results a threat to the free flow of scientific information?

Although the new processes of the commodification of academic research may differ in their degree of intensity between different states or regions of the world, the following common trend can be observed at the global level: academic science is defined more in terms of private goods that must be invested in, exploited and traded, rather than public goods that are made freely available. One of the crucial characteristics of these changes is the demand for the extension of property rights of the research work performed at academic institutions.

The authors of the latest *Handbook of Genetics and Society* (Atkinson, Glasner & Lock 2009) hold that these changes have been nowhere more profound than in the field of genomic science. Indeed, numerous nation-states are pointing to genomics as the motor for new forms of the knowledge-based economy, the emergence of new industrial sectors, and the commercial development of new medical interventions. In this new bio-economy, there is an enormous increase in the interdependence of the international flows of goods and services, direct investment, technology and capital investment and extension of intellectual property rights.

Taking these changes into account, there is a need for re-thinking the new social function of academic science. If we are witnessing an extreme redirection of science towards private commodity, does this mean that the main part of scientific knowledge will finally be privatized and locked outside the public domain?

In my view, it would be wrong to exaggerate the threats connected with the recent processes of the commodification of academic science, even though some critics of the changing role of academic science occasionally paint bleak scenarios for the future (see for example: Goldfarb & Henrekson 2003; Nelson 2004; Van Looy et al. 2006).

The critics of the commodification and commercialization of academic research warn against two possible negative effects.

(1) Blockades at the horizontal level, which refer to the interrupted publication channels or delays in publication. In an era of so-called 'pro-

patent science', the traditional forms of dissemination of scientific information, such as the publication of articles in academic journals, are placed in an entirely new situation. Daniel Lee Kleinman refers to a number of different cases which illustrate this risk: the filing of a patent for a basic procedure used in recombinant DNA procedures, the use of polymerase in the amplification of DNA, the university's use of material transfer agreements, etc. (Kleinman 2005). Indeed, the warnings of delays in publication show only one side of the truth. There are many arguments which deny that intellectual property rights represent the biggest threat for the publication habits in academic science. Last but not least, the historical development of science teaches us that scientific patents, whose beginnings go back a few hundred years, did not destroy the free dissemination of scientific information through publication channels. John Ziman wrote that all new scientific knowledge is potential 'intellectual property', with the legal owner empowered to demand payment for its use (Ziman, 2000).
Henry Etzkowitz said:

> Patents are the best 'co-opetitive' knowledge format (i.e., one that combines cooperation with competition) which integrates free access and privatization. They serve an important public interest – access to knowledge – by providing databases for discoveries and publishing them on the web-site. (Etzkowitz 2002, 57)

(2) Blockades at the vertical level, which refer to the transfer of knowledge from the academic to the industrial sector. One of the concerns of the advocates of public science is that the licensing of intellectual property will limit the free diffusion of knowledge throughout the whole industrial sector, so that specific knowledge may not be used by more than one firm. Is it possible to solve this dilemma with non-exclusive licensing? Licenses are usually granted on an exclusive basis to a single user, because they guarantee a strong degree of market exclusivity. But, licenses can also be granted non-exclusively, to many parties, though non-exclusive licenses are rarely realized in practice. The users of patents belonging to universities are primarily small and medium enterprises and academic start-up or spin-off firms. They demand exclusive licenses from the universities. They prefer to off-

> set the risks involved in further developing protected academic inventions from the start. As in the case of the horizontal flow of scientific information, there are opposite views. Large firms increasingly complain if universities grant exclusive licenses to small and medium enterprises and are thus in unison with the 'ivory tower' critics of university patenting. For big industrial firms, the rise of academic patenting and licensing represents a threat to the market economy. We are observing an interesting paradox. On the one hand, universities, which are traditionally pre-eminent institutions serving the public interest, began to increasingly protect their private interests and commercial benefits. On the other hand, big industrial firms, as the bearers of the paradigm of private interests, are demanding that the universities retain the possibility of free access to knowledge.

There is no doubt that the issue of science as a public and private good is a highly complex one. It raises a great many questions and offers few answers. Recently, academic institutions are orienting themselves more towards serving the economic needs of their communities. This does not necessarily mean that they must replace their traditional functions, but it does mean that they have to complement them. In small countries, such as Slovenia in particular, universities often need to serve a growing variety of functions, from the most basic research, to the most utilitarian training courses and application-oriented problem solutions. This also means that the universities in Slovenia are already entering into a new mode of knowledge production.

The intermediary structures of science as part of organized policy efforts to interlink academic science and industry in Slovenia

The role of organized policy efforts cannot be neglected when discussing the various drivers of the recent processes of the commercialization of academic science. It is impossible to expect that spontaneous socio-economic processes on their own will lead to a change in the traditional institutional structures and value patterns in academic science, especially in small transitional countries such as Slovenia. The newly established intermediary structures have become important policy instruments by incorporating diverse forms of organized policy efforts to interlink academic science with industry. They have achieved a leading position, due to the successful integration of various socio-economic agents. Generally speaking, they are still relatively loosely and openly defined, last but not least because they are populated differently in different countries. Nevertheless the formal designation of various types of intermediary structures is not as important as their ability to perform their socio-economic functions successfully. Indeed, the effect of intermediary structures on the surrounding environment encompasses more than just the transfer of academic research results to industry. The intermediaries are building a much more complex network of many diverse stakeholders and actors that are to be part of these networks. The specialist literature provides various descriptions of organizations that refer to intermediaries: (1) third parties, (2) intermediary firms, (3) bridgers, (4) brokers, (5) superstructure organizations, etc. (see, for example: Howells 2006; Wright et al. 2008).

In Slovenia, various intermediary organizations for linking the academic research sector with industry have been formed over the past one and a half decades. But it is difficult to find their lowest common denominator, in spite of the fact that all of the newly created intermediary structures in Slovenia should serve the function of socio-economic progress. Let us present a brief review of their landscape (Mali & Jelnikar 2008):

(1) The national technological platforms in Slovenia have been created as a response to an initiative of the European Commission. European Technology Platforms (ETPs) were first introduced in the EC Communication 'Industrial Policy in an enlarged Europe' in December 2002. The ambition was to bring together R&D-relevant stakeholders with various backgrounds (e.g. regulatory bodies at various geo-political levels, industry, public authorities, research institutes and the academic community, the financial world and civil society) who would develop a long-term R&D strategy in areas of interest to Europe.[2]

The platforms also had a mandate to help further mobilize private and public R&D investments (for example: Barcelona target of 3 % GERD by 2010). The setup of an ETP follows a bottom-up approach in which the stakeholders take the initiative and where the European Commission evaluates and guides the process. In Slovenia there are currently 24 national technological platforms: a fuel cell technology platform, a textile technology platform, a construction technology platform, a photovoltaics technology platform, a forest based products technology platform, a clean water technology platform, etc.

(2) The technological clusters in Slovenia are the predecessors of technological platforms. The main purpose of their creation was to increase the comparative advantages of domestic technologies in the global environment. The technological clusters should encourage the formation of technological centres, incubators and other types of innovation networks. The first technological clusters were created back in the mid-1990s. They mostly link the academic research community and the small and medium enterprises through regional innovation networks. It is difficult to precisely determine the current number of technological clusters in Slovenia, because some of them are no longer active or they are in a phase of transformation into technological platforms.

(3) The technological parks in Slovenia are those intermediary organizations that provide the organization and infrastructure for the development of technology-based entrepreneurship. They motivate, verify and assist in the realization of entrepreneurial initiatives through a concentration of expert and organizational skills, infrastructure, etc. They are geared to innovative small and medium enterprises with a high potential for growth. Their mission is to ensure a top-quality business support environment for the transfer of research findings and innovative commercial ideas to successful and internationally competitive technological entrepreneurship. There are currently 4 technological parks in Slovenia.

(4) The innovation incubators at the universities in Slovenia try to follow the recent global trends to promote entrepreneurship among academic

staff and students. The innovative ideas that are generated in universities should thus be realized in real applications. The incubators should offer complete support to newly developed enterprises, helping them to overcome all difficulties involved at the beginning of innovation processes. At present there are innovation incubators at three Slovenian universities: the University of Ljubljana, the University of Koper and the University of Maribor.

(5) The centres of excellence in Slovenia were established in 2004 as an institutional response to the EU-wide endeavours to establish stronger connections between the scientific and the business sector. The centres of excellence receive substantial financial support from the European Structural Fund.

In policy terms, the intermediary structures should not only play the role of mechanisms for the transfer of knowledge from academic science to industry, but also – to quote Jeremy Howells – 'the role of animator to create the new possibility and dynamism within the scientific system' (Howells 2006, 720). In Slovenia, this progressive function of intermediary structures has not yet been fully implemented. While the density of institutions in the role of intermediaries is increasing, they are still encountering much institutional inertia.

The relevance of the centres of excellence in the context of the emerging converging technologies

Among the new science intermediary structures, the centres of excellence in particular tend to focus on those new technologies that are expected to have a strong potential for future application. To quote Eric Beerkens:

> The new technologies such as nanotechnology and biotechnology are not equivalent to applied research, but take the form of strategic research. Strategic research is basic research carried out with the expectations that it will produce a broad base of knowledge, which is likely to form the background to the solutions of recognised current or future practical problems. (Beerkens 2009, 156)

In the context of the new European knowledge society, the centres of excellence are increasingly seen as an important mechanism for boosting interdisciplinary and inter-sectoral co-operation. It is also a fact that the centres of excellence have emerged as one of the most promising intermediary structures in the European Union.[3]

They receive support at the regional,[4] the national and the EU level and are normally funded by several partners, e.g. the industry, the state, the European Commission etc. Today, they are increasingly organized along the following three lines: the concentration of R&D human resources, user orientation and cross-disciplinary links.

In Slovenia, centres of excellence did not emerge until 2004. They generally appeared as consortiums of partners from academic science and industry, with complementary knowledge and skills and with a long experience of previous co-operation. In the period 2004–2009, there have been 10 active research centres of excellence: the Centre of Excellence for Biotechnology with Pharmacy (CoE BF), the Centre of Excellence for Environmental Technologies (CoE ET), the Centre of Excellence for Advanced Metallic Materials (CoE AMM), the Centre of Excellence for Materials for Next-Generation Electronics and Other Emerging Technologies (CoE NMR), the Centre of Excellence for Supercritical Fluids (CoE SCF), the Centre of Excellence for the Comprehensive Management of the Fragile Natural and Cultural Landscape of the Slovenian Karst Region (CoE Fabrica), the Centre of Excellence for Information and Communication Technologies (CoE ICT), the Centre of Excellence for Nanosciences and Nanotechnology (CoE NiN), the Centre of Excellence for Functional Genomics for Health (SCF), the Centre of Excellence for Advanced Control Technologies (ACT).

In conceptual terms, centres of excellence all around the world are based on academic research-based systems of contacts between academic science and industry, which combine basic and applied research with a broader education mission (see, for example: OECD 2003).[5]

In Slovenia, the partners included in the centres of excellence come from public research institutes, universities and industrial firms. A total of 138 partners were involved in the centres of excellence in the period of 2004–2009. The centres of excellence still operated in a fragmentary manner, with a large number of researchers only partially involved in their activities. One of the reasons for this situation is that the centres of excellence were formally internal intermediary organizations, i.e. that they were situated at public research institutes or universities.

The potential importance of intermediary organizations in effecting knowledge transfer depends on the various forms of the transfer of knowledge. The un-codified forms of transfer of knowledge are more important in some types of intermediaries than in other types. The results of our bibliometric analysis demonstrated that the centres of excellence in Slovenia are still more oriented to the classical forms of knowledge transfer (Mali 2009).

As can be seen from the table above, the difference in the number of published articles (publication productivity) and in the number of patents (innovation performance) is considerable. The number of publications and citations far outstrip patents and innovations. The majority of the reviewed centres of excellence show a low level of patenting activity. The number of co-authored articles between academic research and industrial partners involved in the centres of excellence is also very low.[6]

The same is true for the number of newly established spin-offs and start-ups. Less than half of all the centres of excellence have succeeded in establishing 1 to 2 spin-offs. This represents a big deficiency for Slovenia, where we still have a relatively weak entrepreneurial economic environment. This deficit is of great significance because the creation of new academic spin-offs and start-ups is of great importance in economic environments, where there is very little downstream industry to which the new emerging technology might be contracted.

The number of supervisions of PhD candidates is also an important indicator of the efficiency of the centres of excellence. It is expected that the networks of academic researchers and industrials will not only take care of the production and dissemination of codified forms of knowledge, but also assume an active role in the training of young researchers. All centres of excellence in Slovenia show a relatively high number of PhD candidates. This is partially the result of official Slovenian R&D policy in the 'Young Researchers Program' (see more: Mali et al. 2008). This policy action is designed to promote a more flexible procedure for the selection of senior researchers who can take the role of PhD supervisors. This step has opened the way for experts from industry to act as co-supervisors for PhD candidates.

Table 1. The research performance of the centres of excellence in Slovenia in the period of 2004–2009

Indicators	CoE NiN	CoE ICT	CoE ME	CoE BF	CoE ET	CoE SCF	CoE NMR	CoE ACT	CoE AMM	CoE Fa-brica
No. of articles indexed by ISI	955	29	280	478	111	138	161	28	179	478
No. of citations (ISI)	18623	199	8064	8500	8211	1343	46	537	808	125
No. of co-authored articles	10	2	38	50	6	11	9	8	86	6
No. of national patents	16	2	25	6	2	3	6	1	5	0
No. of international patents	13	1	8	16	0	0	11	1	5	0
No. of innovations	7	0	123	6	4	0	8	0	52	6
No. of spin-offs and start-ups	2	0	1	0	2	0	0	0	1	0

Conclusions

The relations between academic research and the business sector are in a period of transition around the world. This transformation represents a complex and multidimensional historical and social process and includes the creation of new intermediary structures in science. These have become important instruments in the new processes of the commodification of academic research. The intermediary structures have now achieved a leading position as a policy instrument for the transfer of knowledge from the academic to the industrial sphere, due to the integration of various socio-economic stakeholders. The role of the centres of excellence is of primary importance here, as these centres tend to focus their research on the newly emerging technologies that are expected to have a strong impact on further social and economic development. This requires not only a new role for the centres of excellence, but first of all, a new role for the academics who work in them. The centres of excellence cannot act as closed clubs, providing only for internal excellence, but must also strive to extend excellence outwards. They must be oriented towards the formation of partnership types that will retain the capability to conserve and further develop the networks formed and also continue beyond the financial support by the European structural funds or national governments.

In the case of Slovenia, it would be unrealistic to expect that these changes will occur overnight. Last but not least, the Slovenian centres of excellence have only been in existence for a period of less than 5 years. Notwithstanding, some progress towards the previously described goals has already been made. Some centres are strongly oriented towards the new concept of converging technologies. This has been very clearly demonstrated by the Centre of Excellence for Functional Genomics for Health, in which molecular biologists, geneticists, biochemists, doctors / veterinarians, pharmacists, computer engineers and bioinformaticists work hand in hand.

Notes

1 The first and most comprehensive presentation of the concept of converging technologies was given in the report entitled 'Converging technologies for improving human performance: nanotechnology, biotechnology, information technology and

cognitive science' (Roco & Bainbridge 2002). The study was sponsored by the US National Science Foundation and the US Department of Commerce. As Steve Fuller has noted, the original 2002 US NSF report decisively determines the meaning of the phrase 'converging technologies' (Fuller 2008, 12). Subsequently, a number of workshops and publications edited by William S. Bainbridge and Mihail C. Roco have achieved further progress in the field of converging technologies (Bainbridge & Roco 2006).

2 The Green Paper 'The European Research Area: New Perspectives' (2007) explicitly states that these new institutional forms will allow long-term integration of the new emerging technologies.

3 In Europe, the first centres of excellence were designed on the basis of the US NSF's Engineering Research Centres programme. The US NSF's Engineering Research Centres '(…) discover new industry-relevant knowledge at the intersections of the traditional disciplines and transfer that knowledge to industry, while preparing a new generation of engineering leaders who are capable of leading in industry by engaging successfully in team-based, cross-disciplinary engineering to advance technology' (Parker 1997, 46).

4 A typical case is Finland, where the creation of centres of excellence at the regional level has been promoted through different governmental policy measures, including the European Structural Fund. Here, the relatively extensive network of universities and polytechnics across the country has enabled a more regional orientation of centres of excellence. Even in Finland, however, these institutions are overly concentrated in a few bigger urban areas (Malkamäki et al.; 2001 Miettinen 2002).

5 The program for the creation of centres of excellence in Canada in 1989 was arguably the most dramatic change in the nation's science policy since the National Research Council in Canada was established in 1916. Collaboration, partnership, and excellence were the key words of these R&D policy efforts in Canada (see more: Fischer et al. 2001).

6 This indicator is increasingly gaining importance in measuring the efficiency of intermediary organizations, as it provides an indirect indication of the extent to which scientists from the academic sphere and scientists from the industrial sector are oriented towards the solution of the same problems.

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