TURNING SCIENCE INTO TRANSDISCIPLINARITY. SOME ISSUES OF CROSS-DISCIPLINARY CO-OPERATION AT RESEARCH CENTRES OF EXCELLENCE

Dr. Franc Mali
University of Ljubljana
Faculty of Social Sciences
Kardeljeva pl. 5
1000 Ljubljana
Slovenia
e-mail: franc.mali@fdv.uni-lj.si

Summary

In the paper, the theoretical and empirical aspects of scientific transdisciplinarity are presented. The development of recent post-academic science is characterised by a greater orientation to transdisciplinarity in science. The whole 'philosophy' underlying the European Research and Innovation Area places a strong emphasis on cross-disciplinary co-operation. In Slovenia, centres of excellence attracted increased attention when the use of funds from the European Structural Fund (ESF) was involved. A main goal of these new intermediary research structures was to encourage the collaboration of scientific groups so as to bring about better scientific and commercial results. The empirical part of the paper is built on a content analysis of annual evaluation reports prepared by the centres of excellence and interviews with the heads of those centres.

Introduction

The development of recent science has been characterised 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'. The whole 'philosophy' underlying the EU's R&D policy places a strong emphasis on transdisciplinarity in science. For that reason, many steps have been already taken towards the more efficient cross-disciplinary orientation of European scientists. In the paper, attention will be particularly given to centres of excellence. Today, after a few decades of common EU R&D policy actions centres of excellence have been established as new intermediary scientific structures. In Slovenia as a new EU member state, institutional support for these centres of excellence did not emerge before 2004.

In the paper, I first discuss some conceptual issues of transdisciplinarity. After that, I try to present some criticism of the concept of transdisciplinarity. Namely, in spite of the increased use of the term 'transdisciplinarity' little is still known about how this new mode of research operates in practice. There are also some interesting arguments as to why the concept of transdisciplinarity elaborated by the authors of the 'Mode 2' paradigm is more suitable for analysing the centres of excellence as a new intermediary science structure. The main characteristics of research centres of excellence in Europe will be the

next topic of discussion. In the last part of the paper a short presentation of eight centres of excellence in Slovenia will be given.

Transdisciplinarity in modern science

Today the term 'transdisciplinarity' is becoming a buzzword. The prestige of the term rests on the impression that becoming transdisciplinary is 'the right thing to do'. We sometimes encounter very robust definitions of transdisciplinarity. In an OECD study entitled 'Interdisciplinarity in science and technology' the following differentiation between three types of cross-disciplinary research is used: (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; 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; it is accompanied by the mutual integration of disciplinary epistemologies (OECD 1998).

In spite of the growing use of the term transdisciplinarity, little is still known about how this new mode of research operates in practice. In discussions about transdisciplinarity, one can still often find those who think that transdisciplinarity involves scientific work in which scientists of different backgrounds come together practically accidentally. To explain transdisciplinarity in this way means accepting a meaning of

transdisciplinarity which assumes weak forms of scientific integration. Such a 'soft' version of transdisciplinarity is largely rejected by theorists of science and R&D policy decision-makers.

Unfortunately, various studies dealing with transdisciplinarity at the theoretical and conceptual levels do not offer more convincing arguments to reject these soft explanations of transdisciplinarity. It sometimes seems that the growing demand for cross-disciplinary links in science mostly reflect nostalgia for an era when the unification of science appeared to be possible. Namely, in the last two centuries increased fragmentation has accompanied the social and cognitive profiles of scientific history. This fragmentation had led to many scientific specialities and subspecialities found at the end of the 20th century. According to Rogers Hollingsworth, an American theorist of science, science is today 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 analysed by different scientific disciplines (Hollingsworth 2006).

Is it truly possible to come to this form of common scientific core? Many well-known theorists of science doubt this possibility. For example, Dutch R&D policy analyst Arie Rip says that the transdisciplinarity concept has become popular in recent times due to 'policy' reasons and not for 'epistemological' reasons. The situation here is the same as with the concept of 'big science' seen at the beginning of 1960. At that time, this term (big science) became very fashionable. It has been used to describe a form of scientific organisation which was not very much in

accordance with research practice (Rip 2000). The similar view is expressed by the German sociologist of science Peter Weingart. He says that the transdisciplinarity concept is only some sort of normative template for a kind of politically 'correct' science. It cannot be used to empirically describe the change taking place in science of late. Or, as he put it: '*Transdisziplinnaritaet erscheint als eine Steigerung von Interdisziplinaritaet und hat diese wohl deshalb in der Rangskala der Beliebtheit bei Wissenschaftspolitikern und -verwaltern in den vergangenen Jahren abgeloest. Beide Begriffe erfreuen sich groesster Popularitaet*' (Weingart 2001, 348).

Tibor Braun and Andreas Schubert undertook scientometric analysis of the growth of the terms interdisciplinarity and transdisciplinarity in the titles of science policy papers covered by the Science Citation Index database during the last two decades of the 20th century. They pointed out that the growth in this period was exponential, with a doubling time of seven years (Braun & Schubert 2003).

The 'Mode 2' paradigm and transdisciplinarity in science

It seems that we need a broader theoretical and empirical framework to explain how transdisciplinary research functions. The concept of transdisciplinarity in science elaborated by the authors of the Mode 2 paradigm represents a good starting point to rethink the concept of transdisciplinarity within a broader theoretical and empirical framework(Gibbons et al. 1994; Nowotny et al. 2001). The authors of Mode 2 linked the transdisciplinarity concept with two additional factors:

with problem-driven research and research in the applied context. Both factors are important sources of scientific transdisciplinarity. Transdisciplinarity should transcend science in relation to the problems involved. ‘A transdisciplinary mode consists in continuous linking and relinking, in specific clustering and configuration of knowledge which is brought together on the temporary basis in a specific context of application. Thus, it is strongly oriented towards and driven by problem-solving.’ (Gibbons et al. 1994, 29).

In transdisciplinary contexts disciplinary boundaries are less and less relevant. Transdisciplinarity explicitly orients its production of knowledge not around narrow disciplinary problem-definitions but around other definitions derived from the demands of customers and other societal stakeholders. These stakeholders can come from different social spheres: government agencies, private firms, NGOs or social movements.

This new type of knowledge production requires scientists to complement their research activity with many other activities such as skills and management, fundraising, start-up knowledge etc. (It is not so important how this new type of research activity is labelled: instead of the term Mode 2 we could use other terms.) Transdisciplinarity is today often described as a key element in the advancement of science. Many intellectual ‘breakthroughs’ of modern times emerged through the crossing of disciplinary boundaries. We are living in the most exciting period of the human history of science: the human genome has been sequenced, life science is reinvigorating engineering, the information

technology revolution is playing itself out, instruments of unprecedented accuracy and resolution are giving us new insights into the human brain and the nature of the universe. New interactions among social science, engineering and management are beginning to blossom.

Sabine Maasen, Martin Lengwiler and Michael Guggenhein distinguish three types of contemporary institutional practices of transdisciplinary research (for more, see: Maasen et al. 2006). According to these authors the first type of institutional organisation of transdisciplinarity mirrors the attempt of the university system to reform its disciplinary organisations by strengthening ties with non-academic partners through means such as university-industry collaboration. The second type points to similar reforms in 'big science' research institutions. The third type of institutional organisation of transdisciplinarity is an outcome of changes at the micro-organisational level of research projects, partly related to institutional changes such as the growing internationalisation of research programmes or increasing demand from funding institutions for active knowledge and technology transfers between research and practice.

The new European Research Area and centres of excellence in science

Centres of excellence have emerged as a new form of intermediary scientific structure in Europe. The concept of centres of excellence has been used in the last 20 years in many different forms in European countries. Using a very simple definition we could say that centres of excellence are institutional structures where R&D is performed at a world

standard in terms of measurable scientific production (including training) and innovativeness.

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). Especially in this time of the new European Research Area, it has been recognised that Europe needs a large number of sizable and well-known centres of excellence with a decisive impact on the innovation system. Centres of excellence are currently more and more organised along the following three lines: the concentration of R&D human resources, user orientation and transdisciplinarity in science. They are in a continuous processes of reconfiguration but everything so far indicates they have found their place within what was envisioned by the European Research Area initiative. Past experience shows that significant indirect benefits may arise from enhancing the 'visibility' of the existing centres of excellence in Europe.

As already mentioned, the centres of excellence are also important because they represent one of the new institutional forms in which the concept of scientific transdisciplinarity could be more efficiently realised. They receive support at many levels: regional, national and EU. They are

normally funded by several partners: industry, the state, European Commission budgets etc. Historically, the European Structural Fund's intervention in the R&D field has brought strong support for these new intermediary science structures.

Research centres of excellence are transdisciplinary and generally problem-focused in the research they do, demanding 'horizontal' networking across traditional research structures. They involve long-term contractual arrangements requiring a much bigger commitment than traditional projects through the project funding of collaborative R&D. The main objective in many EU countries has been to arrive at concentrations of researchers and scientific infrastructure in the newly established centres of excellence. They are made up of research teams with a common leadership, even though they may form part of different organisations (universities, governmental research institutes, research development units etc.) (Malkamaki et al. 2001).

At the European level, since the start of establishing the centres of excellence there has been a significant risk that industry and service sectors in one country will not sufficiently exploit the excellent resources found in other countries to improve their innovation performance. Only the effective transfer of knowledge can increase levels of science and technology throughout the EU and allow the emergence of new local 'niches of excellence'. In some EU countries, there is a really strong regional focus. A typical case is Finland. In Finland the creation of centres of excellence at the regional level has been promoted through different governmental policy measures, including the EU's Structural

Fund. Here, the relatively extensive network of universities and polytechnics across the whole country has enabled the more regional orientation of centres of excellence. Notwithstanding this, even in Finland these institutions are overly concentrated in a few bigger urban areas (Miettinen 2002).

In the context of the strategy of the new European Research Area, centres of excellence are increasingly seen as an important mechanism for boosting co-operation between the academic research sector and the business/enterprise sector. The centres of excellence are thus one of the most important policy instruments for reducing the so-called European Paradox. Namely, the European Paradox means that Europe is playing a leading role in the world in the provision of highly skilled researchers, but it fails to orient these researchers to care for the commercialisation and commodification of their results. The European Paradox has been in the last few years the political cornerstone of the EU's involvement in science and technology. It is hence little wonder that the European Commission has exposed it as a mantra justifying the need for concerted European actions (for more, see: Borras 2003).

Research centres of excellence evolve continuously. Although the physical concentration of excellent researchers is still a key factor in research productivity, advanced ICT tools progressively allow effective interaction in networks. For example, in the 6th EU Framework Programme networks of excellence were established. These networks of excellence were designed to strengthen scientific and technological excellence on a particular research topic by integrating at the European

level the critical mass of resources and expertise needed to provide world leadership. This expertise has been networked around a joint programme of activities principally aimed at creating the gradual and durable integration of the research capacities of the network partners.

Centres of excellence in Slovenia

In Slovenia, centres of excellence did not emerge before 2004. They attracted greater attention as one a possible intermediary structure when Slovenia began to use the financial means from the European Structural Fund (ESF). EU funds have so far not been a major source of R&D financing in Slovenia. Researchers in Slovenia have been relatively successful in the 6th Framework Programme and in Eureka. The European Structural Fund is important for Slovenia because it mainly supports the activities of eight centres of excellence and investments in research infrastructure by technology parks or clusters. Generally speaking, the European Structural Fund is intended to narrow the gap in development among the regions and EU member states of the European Union. Together with the Cohesion Fund it represents 35% of the Community budget. Therefore, both funds are the second largest budget item in EU Commission (after the Common Agricultural Policy).

The initiative to support the establishment of centres of excellence by the Slovenian government (the Ministry of Higher Education and Science) and to also engage in this support the resources available from the European Structural Fund was taken on the basis of several R&D policy documents in Slovenia in which the need to promote closer links between

academic research units and the business/enterprise sector was stressed as one of the key objectives. (These policy documents such as the National Research and Development Programme and the National Development Strategy also indicate the priority research sectors for the near future in Slovenia).

In that sense, Slovenia as a new EU member state benefits from the change of 'philosophy' underpinning the European Structural Fund. In the context of the EU's Lisbon strategy, the role of the European Structural Fund is increasingly focused on investments in R&D and innovation programmes at the regional level. It is in contrast with past interventions pursued by the European Structural Fund which focused more on the provision of basic infrastructure. For Slovenia, there are additional advantages in the change of 'philosophy' in the distribution of money within the European Structural Fund. The well-known European Paradox in the case of Slovenia is even more accentuated than in several other EU countries. Although the organisation of intermediaries such as centres of excellence, technological clusters and technological platforms are declared as a priority in different policy documents, the national model of financing of R&D activity in Slovenia is still quite traditional. Financial support is mostly oriented to the disciplinary structure of science. The same is true of the existing R&D evaluation system in science.

Centres of excellence in Slovenia mostly emerged as a consortium of partners with complementary knowledge and skills and with previous long experience with co-operation. Larger investments in intellectual

capital enabled in the centres of excellence a new way of partnership co-operation better adapted to the challenges of recent processes of commercialisation and commodification of scientific knowledge. Another interesting characteristic of R&D at the centres of excellence is that they join research teams at research institutes, universities and business firms on an equal footing: a more common form of co-operation is that business commissions the research carried out at a single institute or research unit. The most welcome innovative element of the centres of excellence in Slovenia is that they have introduced the more transdisciplinary type of R&D.

In Slovenia, there are currently eight research centres of excellence. Let us give a short snapshot of these centres of excellence. After that a main issue of recent activities of the centres of excellence will be discussed; namely, how to increase the practical skills of the personnel included in consortiums to manage intellectual property rights. The overview of the situation in Slovenia is based on a content analysis of annual evaluation reports prepared by the centres of excellence for the Ministry of Higher Education and Science in Slovenia. Concomitantly, additional information stemmed from interviews with leaders of the eight centres of excellence. The interviews were conducted in May and June 2007.

Let us begin with a short overview of the country's centres of excellence.

1. The centre of excellence for biotechnology with pharmacy deals with the structure and sequence of biomolecules with the help of nuclear magnetic resonance (a special spectroscopic method). These fundamental

insights into molecules are the basis for the production of pharmaceutical preparations. The partnership involves researchers from the National Institute for Chemistry and people from the R&D units of Lek and Krka, two very successful pharmaceutical firms in Slovenia.

2. The centre of excellence for environmental technologies focuses on urgent environmental problems in Slovenia (activities to put into effect sustainable methods of water protection and purification). The interest is also oriented to the issues of (thermal) recycling and the reuse of waste.

3. The centre of excellence for advanced metallic materials consists of a multidisciplinary group of researchers from the university, academic research institutes and industrial firms. Research activity is oriented to the development of new soft magnetic and getter materials. This centre was built on the traditionally good co-operation between researchers at the Institute of Metals and Technology and managers at the leading steelworks and steam power plants in Slovenia (Acroni, Unior, Impol).

4. The centre of excellence for materials for next-generation electronics and other emerging technologies endeavours to find solutions to the needs of the Slovenian electronics industry. In this sense, the main R&D activities are oriented to magnetic materials and intermetallic alloys, microstructures and microsystems, the new generation of elements and devices for protection against transient surges, hybrid materials and structures, and complex materials for new technologies.

5. The centre of excellence for supercritical fluids seeks to contribute to a better understanding of the processing of materials with supercritical fluids. High-pressure spray processes involving the use of compressed gases to produce solid particles in the micro- and nano-scales have found their first industrial applications in the field of pharmaceuticals and food technology.

6. The centre of excellence entitled Fabrica aims to construct a series of concrete technological and methodological solutions for the comprehensive management of the fragile natural and cultural landscape of the Slovenian Karst region.

7. The centre of excellence for information and communication technologies is a consortium of partners from universities, national research institutes and industry with complementary knowledge and skills and with long experience in co-operation in national and international research projects. Consortium members are involved in many complementary projects to achieve synergic effects: voice and graphic technologies in information and communication technologies, command of the research process and information technologies in developing solutions for electronic business, wireless communication platforms etc.

8. The centre of excellence for nanosciences and nanotechnology. As to the activity of this centre it is necessary to say that the EU Commission's bibliometric analysis showed that in the past few decades Slovenia has achieved excellent results in nano-science. For example, the number of specialised articles on nano-sciences per citizens ranked Slovenia in 7th place in the world (European Commission 2003). Accordingly, the formation of

the centre of excellence for nanoscience and nanotechnology provides an opportunity to bring key researchers and their institutions together as well as several members of the industrial community. Currently, there are six research institutes and research units within the universities co-operating in this centre of excellence and 26 business enterprises. The centre of excellence carries out the following major research projects: nano-materials, nano-devices, electronic devices with nano-elements, and bio-sensors.

The research activities carried out at the centre of excellence on nanoscience and nanotechnology are transdisciplinary. They join physics, chemistry and electro-technics together. High-tech equipment needed for research in nanoscience and nanotechnology is extremely expensive in the Slovenian circumstances. The formation of such a centre has enabled researchers to gain access to sophisticated research equipment. A good research infrastructure means the ability to generate increased support from industry and the further strengthening of joint research encompassing basic, applied and development projects. Further development of research capabilities (both human resources and research equipment) enables the centre to compete for additional national and international financial support, resulting in more research work and the ability to attract young researchers to this promising research area and, in the near future, to become a self-sustaining organisational unit. Overall, the creation of the centre of excellence in nanoscience and nanotechnology has been one of the most positive factors in Slovenian R&D policy which, due to the still restricted national resources for R&D, would not have emerged without the European Structural Fund.

Based on extensive interviews with leaders of the centres of excellence the lack of practical skills to manage intellectual property rights in the established consortiums of centres of excellence was pointed out as a serious problem. The interviews showed there is still a lot of ignorance in terms of the ownership of intellectual property. For example, in the framework of our interviews the principal investigators of projects did not give extensive answers on how relations among partners are regulated concerning the right to revenues arising from emerging patents and other licensed knowledge. It was impossible to obtain any (reliable) information about the forms of undisclosed technologies produced by researchers involved in the partnership. Namely, procedures ensuring that staff currently inform about new inventions have not yet been established. In Slovenia there is no legal act providing that a researcher's personal ownership of an invention can be transferred to the institutional level. The legislation restricts the role of academic institutions. Individual researchers retain personal rights to inventions. The general opinion of the principal investigator was that intellectual property rights should primarily safeguard the benefits of individuals, not institutions. Consequently, mechanisms for the evaluation of invention disclosures at the level of research organisations have still not been developed.

Conclusion

It could be said that centres of excellence in all European countries aim to refocus R&D activities towards inter- and trans-disciplinary problem areas which are also particularly important for the business/enterprise sector. All

activities at the centres of excellence are strongly connected with problem-driven research and with research in the applied context. As already noted, both elements are important sources of transdisciplinarity in science. The biggest deficiency in Slovenia is that policy measures to support the activities of the country's centres of excellence are too much in the hands of the state. The state is the key stakeholder which formally determines the legal and institutional framework for the functioning of intermediary science structures. The government is increasingly emerging as a controller of the centres of excellence. Unfortunately, research centres of excellence spend a lot of time and energy on administrative issues: preparations of public calls to tender, the selection and negotiation process with project applicants, complicated procedures in signing contracts particularly for projects with consortium agreements and even more complex reporting and the claiming of funds. All of this has resulted in the relatively negative image of these new intermediary science institutions in Slovenia, particularly where the subject of co-financing is research and not infrastructure or construction work.

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