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We Have Research Infrastructure - Can We Cooperate?

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Abstract: Business-academia collaborations are widely studied by scholars and mostly viewed as an important source for innovation and R&D. In this paper we examine one of the tools which can help in this cooperation but that is usually overlooked: the role of research infrastructure. Without a doubt, infrastructure has great scientific impact, though its socio-economic importance is not yet studied in depth; the need to measure this importance is becoming more and more necessary from both the policy and societal side. There are certain characteristics that have to be taken into account when studying research infrastructures; their role both in science and the economy is equally important. While most of them are designed for scientific use, economic impact is expected through their usage – this problem should be solved with their involvement in the already existing technology transfer activities, which research infrastructures can improve through their presence. Based on current data we propose to use the Pareto-principle for determining the industrial usage of a research infrastructure in general; however, the characteristics of different scientific branches have to be taken into consideration as well.

Keywords: Research Infrastructure; University; Hungary; National Infrastructure Assessment; Survey

Introduction

The most influential of the current innovation policy trends is possibly the Triple Helix model, which was presented 20 years ago and has been being adjusted ever since, to tackle business-industry and government relations (Etzkowitz 2003; Leydersdorff 2012). In this paper we will examine one aspect of this model and one element of this aspect: the business-academia cooperation and the role of research infrastructures within it.

Business-academia cooperation has long been one of the most widely studied fields in science policy, along with models of technology transfer methods. The studies of this field usually approach the topic from two sides. One is the technology transfer approach, which tries to identify the sources and links of innovation, such as the contingent effectiveness model (Bozeman et al. 2015). This approach has the major problem that usually it is not understood – "alternative models, with their multiple feedback loops, look more like modern artwork or a 'plate of spaghetti and meatballs' than a useful analytical framework" (Godin 2006) – a problem persisting since long time.

The other approach that promotes the importance of universities in the national innovation system is the Triple Helix model, in which that role of universities in their "third role" as knowledge holders in economic development and boosting national competitiveness is beyond question (Etzkowitz 2003; Rasmussen et al. 2006; Ambos et al. 2008; Banal-Estonol et al. 2015;). Collaborations between industry and universities lead to more intense R&D (Bozeman 2000) and also to an increase in licensing activities, and through this R&D's impact on innovations for the business sector as well (Bonaccorsi et al. 2013). It's only rare that – as studied in-depth by

Leten et. al. 2008 - these cooperative projects have an effect outside of their immediate region and create spillover effects for the local economy, higher education, etc. only there; a reason which indicates there should be some level of cooperation in each region of a country – ideally, through a university in each region. Also, while studies argue that innovation is important, it has not been extensively examined what would be the acceptable level of cooperation between business and academia. A recent attempt has been made to define this, and found that for the purpose of research output a "balance" between industry and academia fosters the most innovation; "research output shall be maximized at intermediate degrees of collaboration, i.e., when the industry is involved in some but not in all the projects of the academic." (Banal-Estanol et al. 2015)

If we cooperate?

While the innovation models try to find an answer to the process of innovation and knowledge–technology transfer, triple helix identifies the actors of the national innovation system. It has not been examined what the tools are which they use to be a part of the triple helix and make technology transfer possible. It' is clear that just because an entity is a business enterprise or a university it will not become part of the triple helix. It needs certain characteristics, like innovative abilities, or the harder facts like R&D personnel, R&D laboratories, innovation strategy, and the like. For the governmental sector tools could include policy measures, tax incentives, strategies and grants offered for innovation. The academic sector has a resource that is often overlooked with regards of innovation impact –this is the research infrastructure. Research infrastructures can take various forms, from the big, physical infrastructures we have all heard of – CERN, ELI, ESO, etc. – to the form of databases, especially in the field of social sciences and humanities. Often it is these infrastructures that make it possible for a researcher to contribute to innovation, and the knowledge on how to use these infrastructures pushes companies toward the academic sector in R&D matters. Although "research infrastructures are recognized as key elements in research and innovation policies, for boosting scientific knowledge generation" (G7, 2015), only recently have questions been raised on their effective and measurable impact on the economy or the social challenges – together called socio-economic impact (Barzelay 2001). This change in attitude has a clear trend, however. Back in the 1950s simply stating that a research infrastructure was important for some scientific reason was accepted by policy makers and society, but this attitude gradually changed, especially with the economic crisis in 2008-2009 (Elzinga 2012). Today every research infrastructure, whether already existing or planned, pays great attention to proving its socio-economic impact.

Academia and higher education are usually viewed in the triple helix as the actor that provides R&D capacity, mostly through human resources. Since there is a steady supply of students, professors and PhD students, this sector provides the backbone of the researchers. They are the users of the "tools", the research infrastructures, mainly because they are skilled in using them, or from the policy side because they have access to and information on them.

When looking at the cooperation level between universities and business, we must be aware that these sectors have conflicting goals: the academic sector usually wants to publish its findings, while business sector wants commercial success (Trajtenberg et al. 1997). Interestingly, when we examine the results of these priorities, for the short- and middle term period we find that purely academic efforts lack results in a business sense; but in the long term these academic results fare better than their business counterparts. This indicates that academic research, whether aimed at basic or applied research, does have an effect in the long run. Czarnitzki et al. (2011) find that the effect occurs after 10 years, while other studies argue that basic basic research results have an effect in some 15-20 years of time (Eagar, 1995). For basic research this is more or less acknowledged widely, for applied research these results are less evident. This also means that there is an optimum level of cooperation, which should be defined. But to know this level, first we have to measure the current level exactly.

The problem of different equipment needs cannot be overlooked, either. Just like in the case of publication vs. commercialization, there is a gap between the business sector's needs and the scientific needs – the latter needs "cutting-edge" technology, but business settles for the technology available with less cost, without doubts and more importantly almost instantly.

The above-mentioned restrictions do not make cooperation easy for the two sectors, but there are other issues they have to deal with, as well. We will show these in the example of Hungary, and provide solutions for some of them. Various measures have been introduced to define the innovation levels in Europe; some of the best known of them are the European Innovation Scoreboards (IUS) and the Community Innovation Survey (CIS) –

both indicate Hungary has been a moderate innovator for years. For the purpose of this analysis we will use the data of CIS (2012), which is the most recent.

Cooperation has certain indicators – some are available for the whole of Europe. One of these indicators is measured by the Community Innovation Survey (CIS) regularly. As the scope of this paper is to present the situation through Hungary's example (in international comparison, of course), we will show the figures most relevant for our topic. In Figure 1 the results of two questions from the CIS questionnaire can be seen, with the results ranked according to the percentage of business–higher education cooperation. The two questions were selected because of their direct involvement in business–academia cooperation measurement; we will also match them to a survey's result on the infrastructural aspect of these collaborations.

Note that for visualization purposes some countries were left out of the figure; we included the major research infrastructure owners and the Central and Eastern European countries for comparison.

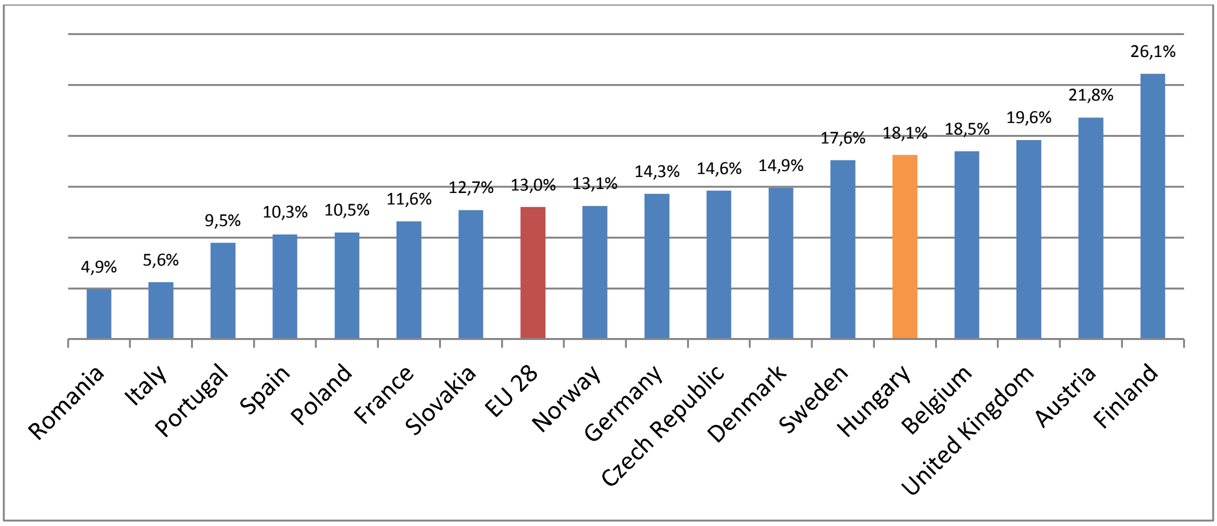

Figure 1 Enterprises cooperating with universities or other higher education institutions (CIS 2012)

In Figure 1 it can be seen that Hungary fares well in this comparison; based on this figure we can say that business–higher education cooperation is high. Of course, it must be noted that this result is true only for the medium-sized and large companies, as CIS methodology measures mostly these two categories. For Hungary, therefore, this figure means that the medium-sized and big companies cooperate with higher education – as these companies are the most likely to be users of sophisticated research infrastructure, we find it to be a good indication that this branch of the business sector has active connections to higher education.

If we look at t Fig. 2, this time basing the ranking on the cooperation with government, public or private research institutes, the picture differs.

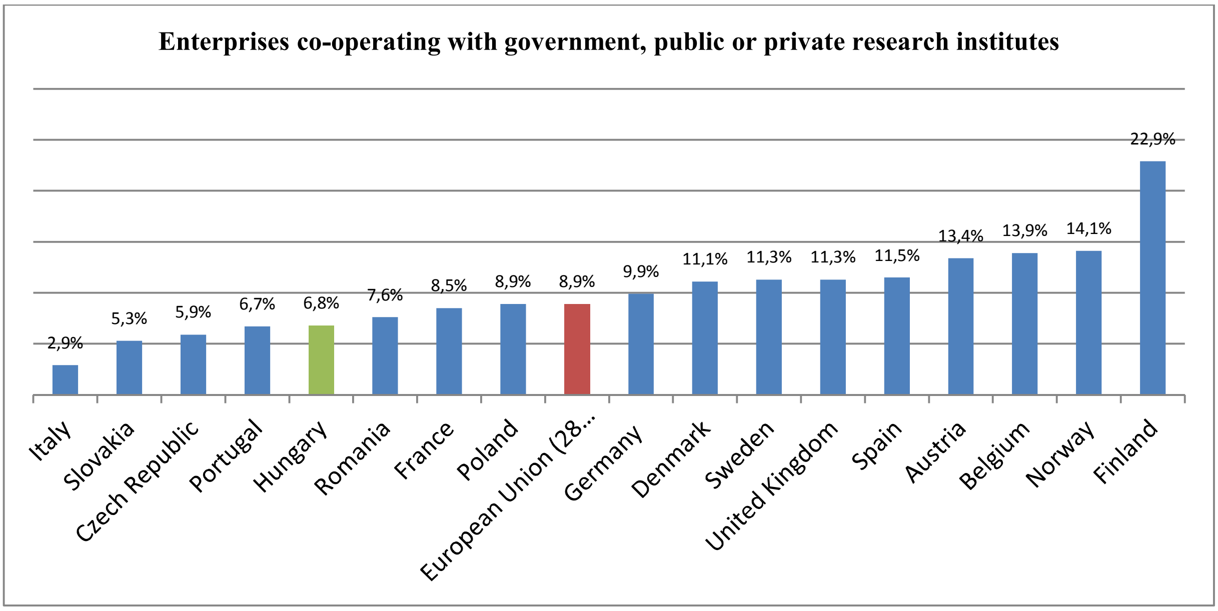

Figure 2 Enterprises cooperating with government, public or private research institutes (CIS 2012)

How we do it? Cooperation in Hungary

For Hungary the great majority of research infrastructures and research institutes are government property, thus we can safely assume such cooperation involves the use of some research infrastructure in most cases – we will provide direct evidence of this shortly. The most striking difference is the fact that, while cooperation between universities and business is relatively high, for the research institutes the figures are much worse. An explanation might be that companies do not make use of the research infrastructure. Considering the findings of a German study (Dornbusch and Neuhäusler 2015), multinational companies tend to be the most active in long-term R&D projects, while SMEs usually try to adapt the existing technological trends usually present at the universities. Research infrastructures are usually used as part of a greater project, or for projects with significant uncertainty – neither area is SME driven. For Hungary, the involvement level of research institutes in business cooperation through research infrastructures is supported by the results of a Hungarian infrastructure survey conducted in 2014. One of the questions of this survey was the usage of the research infrastructure by business users. After analyzing the data of the 328 infrastructures and providing a methodology for defining the cooperation levels (Deák and Szabó 2015), we found that the average cooperation level is 6.77% (Figure 3). Cooperation levels were defined based on the research infrastructure's usage by enterprises and also taking into account the overall usage of the infrastructures (both values were provided by the research infrastructure owners).

Upon examining the data above it is evident that cooperation levels between academic research institutes and the business sector is quite low. A reason might be, that these institutes tend to provide services to the business sector not by giving direct access to their research infrastructures; thus the business sector uses these infrastructures indirectly, while the research institutes provide human resources who are involved in other, non-infrastructure related activities of the cooperation as well. Therefore, a great part of these cooperation are not considered as research infrastructure-centered. . The question is whether this level could be raised, taking into account that different scientific branches have different possibilities for cooperation with the business sector.

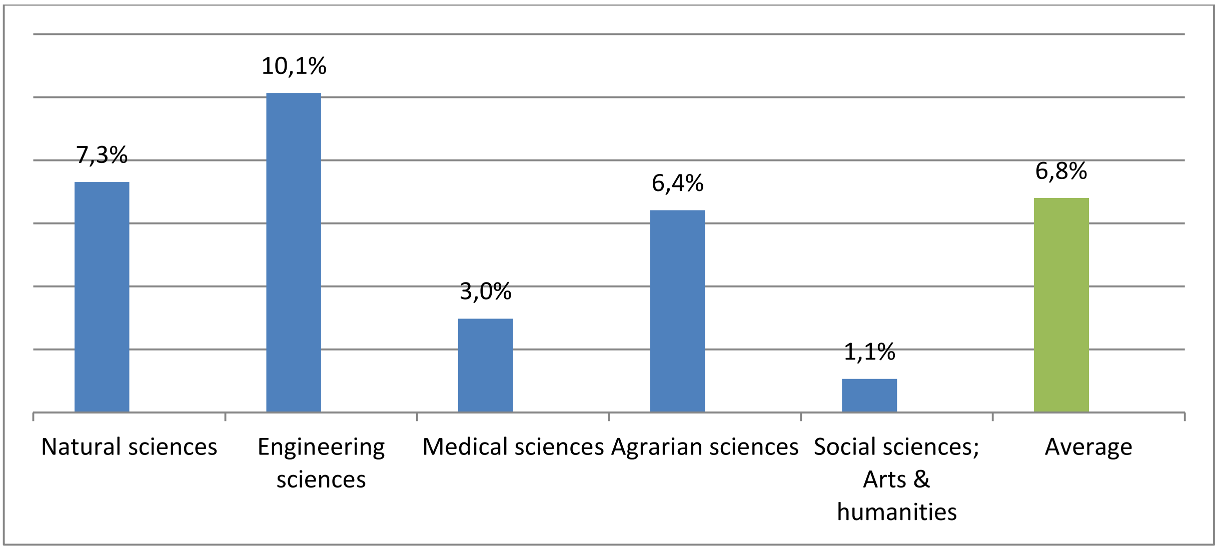

Figure 3 Cooperation levels of different scientific branches with the business sector (Deák and Szabó 2016)

Based on the findings of CIS and the nationwide survey, whose results are representative in terms of quantity for Hungarian research infrastructures, we attempt to define the optimal cooperation level between research institutes. In business sector and university type cooperation ("Enterprises cooperating with universities or other higher education institutions") research infrastructures' play role is less significant as in most cases research infrastructures at the universities are not the main reason and tool of cooperation, there are various other cooperation types (consulting, technology transfer, licensing, etc.) as well. We can assume, however, that research infrastructure usage is the main factor in the "Enterprises cooperating with government, public or private research institutes" type collaborations as the main resource of cooperation of these institutes are the research infrastructures. For Hungary this is supported by the data of CIS and the nationwide survey that can be matched; 6.8% (Fig 3.) of the usage time of research infrastructures by businesses is very likely to cover the same activities as the CIS data on cooperation 6.8% (Fig. 2.). Accepting the CIS category of "Enterprises cooperating with government, public or private research institutes" representative for research infrastructure usage level as well, we attempt to make a suggestion on the optimal cooperation level.

If the business usage of research infrastructures were 50%, it is clear that they could not serve the original function of basic research institutions, because this level would not leave room for cutting-edge research – the research time of research infrastructures is limited by several technological and scientific factors (installing, preparation, various user groups, etc.); moreover, current usage levels indicate that such increase would be unrealistic. The currently low level of cooperation is not a must, however – as we saw, various branches of science perform better in Hungary than the average, with up to 10% cooperation. As seen in Figs. 1 and 2, the cooperation levels both for research institutes and universities are roughly around 20% in the best cases. Based on the currently low usage of research infrastructures in Europe, it seems fair to expect a Pareto-principle of 80% "pure" scientific usage and 20% industrial usage for research infrastructures' cooperation level with industry: their use above 20%, based on cooperation levels, seems unrealistic. While cooperation for higher education is higher, it still rarely reaches more than 20% – for research infrastructure, however, we can expect roughly the same amount, weighted by scientific branches if necessary.

This increase will not occur by itself. To achieve this, there is a need to form synergies between the research and educational activities of universities and the research institutes (academic-higher education) before they can improve their "third role" of "regional innovation organization" and "academic entrepreneurialism" (OECD 1999).Bringing the universities and research institutions together through research infrastructures can greatly contribute to this goal. However, we must take into account that research infrastructures have certain characteristics that influence their usage by the business sector. These characteristics are shown through the stages of research infrastructures' life cycle in Fig. 4 (based on G7, 2015).

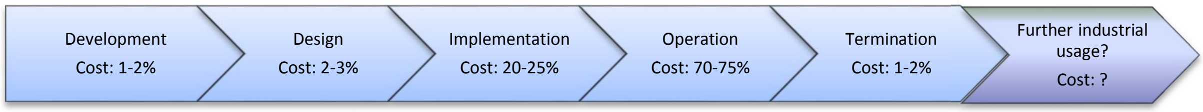

Figure 4 Lifecycle of a large research infrastructure with the average costs for phases. (Based on G7, 2015)

Development Stage: In the development stage, where the idea of forming a research infrastructure arises, the business sector is rarely involved, as research infrastructures are – and should be! – built for scientific purposes in the first place. However, contrary to the current practice of thinking on business usage, AFTER the key decisions have been made it would be a good idea to think of the infrastructure as being part of the innovation system, thus involving potential business users in the design phase as well.

Design Stage: If not done during the development phase, the government or the funding organization should involve the business sector at this point. At an operative level they can provide data and expertise for the construction and make suggestions for business use as well. The socio-economic impacts should be defined at this stage at the latest – contrary to today's practice, where this is considered as a burden. It is interesting to see the views on a research infrastructure on why the business sector was not involved in this phase (EPOS, 2015). They state that there are no open access data in the involved industry, and there is a potential conflict between industry partners regarding the research infrastructure. Moreover, they claim there is limited possibility to commercialize the data products and infrastructure elements – still, they claim also that the business sector will be involved in the future.

Implementation Stage: The implementation phase provides the most opportunities for the business sector in terms of financial possibilities. Companies can be the suppliers for the low-tech products; however, governments mostly support having companies from their own countries act as high-tech equipment suppliers. This is fostered through in-kind contributions, which aim to ensure a certain share of companies involved in the construction of the research infrastructure. In some cases the high-tech content of these supplies is secured through the involvement of academic research institutions in the process. In Hungary, for the construction of the European Spallation Source (ESS), three academic research institutes serve as direct contact points towards ESS to reach this goal. Also, the government agreed that Hungary's contribution will be paid 70% in-kind, meaning that this amount will come back to Hungary eventually. This model is not unique, as most newly designed research infrastructures use the same method whenever possible. Due to the need for showing the socio-economic impacts, the need arose to show the direct economic impact of taking part in the implementation phase of a research infrastructure as well – this can be best assured through in-kind contributions. This cooperation should have the positive side-effect that companies became aware of the future possibilities of the research infrastructure, will use it for business purposes, and will spread the news among their partners.

Operations Stage: In this stage the business sector can appear both as customer and supplier. While governments would support the latter, it is not possible in many cases to have business suppliers – the nature of the infrastructure does not make it possible. Of course, there can be major upgrades or the constant need for some material for research, but the scale for supply possibilities shrinks compared to the implementation stage.

Parallel to this, however, the business users' possibilities become wider. The infrastructures can be used in many ways depending on their nature, mainly for testing, prototyping, measuring, etc. Societal infrastructures can be used for conducting surveys or providing trends. Medical infrastructures have the closest connection to the actual usage, while physical infrastructures' usage is not always evident. For the latter, being mainly built for basic research, the servicing of socio-economic needs is especially challenging.

One response to the socio-economic challenges that has come into practice is "capacity building," which means that there will be the possibility to use the infrastructure in different ways – research opportunities, scientific materials, attracting more students, etc. However, this does not bring much new to the market, as these are created in the process of the usage of the infrastructure – without a "smart" strategy to make actual use of these possibilities, they will not lead to much improvement of the socio-economic impact.

Termination Stage: The last stage is rarely included in the research infrastructures' plan, though it is becoming more and more important with environmental concerns. (Of course this holds true only for some infrastructures.) In some cases the termination may be the decommissioning of the infrastructure (in the case of a single-sited facility), while those that operate through hubs can remain active, depending on their status. The business sector will have a big role in the safe decommission and the potential re-use of these infrastructures. Upon termination one solution may be to use the infrastructure solely for business purposes when possible.

Further industrial usage stage: This stage usually has little importance from the research institutes' view; from the scientific side the infrastructure is considered obsolete. However, while for industrial users it can have importance, this phase should be important for scientific community, as well, as the decommissioned infrastructures could be used (in certain cases) to act as technology demonstrators or educational sites. Both of these activities contribute to the socio-economic impact of science as such, and therefore they should not be overlooked.

To deepen the connections of the research infrastructures to the innovation system is definitely needed. There would be room for business cooperation, and innovation would benefit from it; still, many research infrastructures (not only in Hungary) struggle with making their "products" marketable. This is a problem for universities as well.

A survey made some years ago (Buzás 2004) in Hungary shows that there is no path between being a researcher and an entrepreneur; researchers feel their position is safe compared to the "risky" entrepreneurial world. This has some long-reaching consequences. Most cooperation with business sector is based on personal connections, rather than formal contacts (Bonaccorsi et al. 2013) . This means, that a business sector actor is likely to approach a higher education actor (that he knows of), but is unlikely to have an academic research institute as partner. The academic sector in Hungary is widely viewed, especially from the business side, as an "ivory tower". The situation used to be the same for higher education, but recent measures changed this view.

If we have technology transfer activity?

Academic research institutes are working primary on basic research and use their research infrastructures to this end. In some rare cases spin-off companies are formed for a specific type of activity which can be provided back to the institute, but in the end the use of the research infrastructure remains a privilege of a limited circle – not intentionally, rather because of the lack of knowledge about the possibilities of that infrastructure.

To understand this phenomenon we must see that research infrastructures have special characteristics regarding their connection to the business sector. Usually, researchers have low dedication towards companies; most researchers have the attitude of "I'm a scientist, not a businessman". This is a cultural issue mostly, as researchers usually are risk-aversive and lack entrepreneurial skills, rather, they compete with each other for limited resources (funds) and on top of that they have the demand for publication from the scientific side (Imreh et al. 2013). These are problems for technology transfer, too. However, there are issues which are not so evident for research infrastructures.

In the case of universities there is always a space for knowledge transfer through personal connections for the university and its former students, which can potentially form technology transfer activities. However, as universities usually train their students for research (while most of them never become researchers), it would be far more worthy to train them through research. This would instill a stronger affiliation towards research and towards the research infrastructures, as well. This way more researchers could be created; those who do not become researchers will have information on the research infrastructure, and thus its usage can improve in the future from former students' business activities. This simple methodology change, which would improve the research level as well, could have an enormous impact on research infrastructure usage and through it on the level of innovation – a big socio-economic impact.

Generally, the improvement of research activities (through research infrastructure, but not necessarily only in this way) improves the socio-economic benefits. As seen in a recent study (Guerrero et al. 2015), universities without dedicated entrepreneurial activities have high levels of knowledge transfer, their knowledge capital is very strong, thus they have an impact on economy – the same can be assumed for the research infrastructures as well, e.g. higher research (knowledge) level leads to greater socio-economic impact – although this requires further studies. Also, as the differences between the scientific branches cooperation levels shows, in research infrastructure usage we must take into account that the "products" differ by infrastructure type: even in the same branch, for instance in natural sciences, the results in physics tend to be used through prototypes, while in chemistry through patents – the commercialization of the innovation requires different strategies.

Cooperation with companies should take forms that are understandable for the business sector. There is a clear need for a technology transfer tool that provides "non-scientific-level" suggestions for company problems and acts as a mediator towards scientists. A prerequisite to this would be the improvement of research infrastructure knowledge in general; open days and communication of scientific results widely can help to attract companies and supply information on the infrastructure. To this end there should be a higher level of "technology demonstrator"-type facilities, which show some very evident results of science (e.g. space station, ITER, etc.) rather than putting science itself in first place. These technology demonstrator facilities could be made of infrastructures decommissioned from science and that have no purpose for business either; ideally they are still useful for this demonstration purpose.

When possible, research infrastructures should be used further instead of termination: they should be commercialized, which generates income – but for this it has to be known how an old (for research purposes) infrastructure can be used further by the business sector. It is not an easy task trying to commercialize the research infrastructures; they all have to have a different "sales strategy" and their market is very limited both from the demand and the supply side. Only a handful of companies are able to act as R&D suppliers – in the case of many European infrastructures there is no supplier from the EU for certain equipment. Those who succeed in becoming R&D suppliers in many cases come from the academic sector's spin-offs – they can be actually more successful than their university counterparts, a phenomenon that has not yet been examined.

Also, while it is true that there is an optimum level of cooperation, from the science policy side it must be acknowledged that the income of a research infrastructure will never reach the point where it would cover most of the cost of the infrastructure – there will always be need for state funds if high-level scientific results are sought.

Bearing this in mind, putting in-kind contributions in the first place of measure for the economic impact of the research infrastructure severely simplifies the socio-economic impacts of these infrastructures. A complex evaluation system based on the data provided by the research infrastructures has to be evolved to assess the exact impact, both in a socio-economic and in a scientific sense. There are promising attempts for this (e.g., Technopolis 2011) that can act as a basis for infrastructure evaluation on a proper level.

An increase in the level of cooperation can be achieved if the technology transfer portfolio of universities is strengthened and the research institutes' possibilities regarding their services through their research infrastructures become visible to potential users. While large research infrastructures are indeed paying attention to achieving this – and to increasing their socio-economic impact this way – it seems that each infrastructure's individual technology transfer activity is not being carried out in the most effective way.

While technology transfer is not a primary concern of these facilities – understandably, they are more concerned with science – it seems logical to bring their services activities closer to universities through this strengthening connections to industrial partners. There is the prerequisite of bringing the research infrastructure closer to the university's user community side, so that the infrastructure can be fitted to both the educational and the commercial portfolio of the university. The universities' role of traditional research and education will be strengthened this way, as the results from both of these activities are likely to increase. As shown above, through wider recognition of the research infrastructures the "third role" will be strengthened with the likely increase of cooperation through new opportunities.

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