The need for multiple methods to map, and more refined policy tools to promote, business-academia collaborations: The case of Hungary

Attila Havas
Institute of Economics, CERS, Hungarian Academy of Sciences
attila.havas@krtk.mta.hu

11th Triple Helix International Conference
Bringing businesses, universities and governments together to co-innovate and solve economic, social and technological challenges
July 8-10, 2013, London

Keywords: Types of business-academia collaboration; Multiple methods to map business-academia collaborations; STI policy implications; Hungary

Theme: Mapping university-business relationships, as a sub-theme of *Universities as interactive partners*

Attila Havas, PhD is a Senior Research Fellow at the Institute of Economics, CERS, Hungarian Academy of Sciences, and regional editor of *International Journal of Foresight and Innovation Policy*. His academic interests are in evolutionary economics of innovation, systems of innovation, innovation policy, and technology foresight. He holds a PhD in economics (The Diffusion of New Technologies), from the Hungarian Academy of Sciences, 1997. He has participated in a number of EU-funded research projects on STI policies, innovation and transition, as well as on foresight and prospective analyses, advised several national technology foresight programmes, and has been invited speaker at a number of conferences and workshops.

1 INTRODUCTION[*]

1.1 The main research question

Hungary has all the major elements of a potentially successful national innovation system (NIS): a fully fledged education system; internationally recognised research units both at universities and the institutes of the Academy of Sciences; an increasing number of business R&D units, several of them operated by multinational firms and thus integrated into international networks; a number of government bodies engaged in science, technology and innovation (STI) policy-making and a considerable number of policy schemes in place; various types of professional associations and chambers; a functioning capital market, complete with venture capital funds; a market economy based on private property; creative people; etc. Yet, performance is far from satisfactory. In brief, two major reasons can be thought of when discussing this apparent contradiction. First, although these 'nodes' of the NIS are set up, a number of them do not work satisfactorily, or still fledgling. Second, as innovation studies stress, the major factor determining the overall innovation performance is not the performance of the individual organisations, but the intensity and quality of linkages and co-operation among them. (Fagerberg *et al.* (eds) [2005]; Lundvall *et al.* [2002]; Niosi [2002])

There could be a variety of linkages in successful national innovation system among its players (businesses, academia, intermediary and service providers, policy-makers at various levels). Firms are involved in different ways – formally and informally – and to a varying degree in devising STI policy strategies and actual policy measures. The links between businesses and intermediary organisations (including players offering funds for innovation activities) is also a crucial factor in determining the performance of a given NIS, just as external linkages, that is, the internationalisation of RTDI processes[1] and the impacts of external STI policies, especially those of the EU for its member states. Of these linkages, only academia-industry co-operation is discussed in this paper. In other words, it cannot analyse in detail the major characteristics and operation of the principal players of the Hungarian NIS, and thus cannot tackle the first hypothetical explanation.[2] Rather, it is focussing on some important aspects of the second reason by providing a map of

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[*] This paper draws on various projects, aimed at analysing the Hungarian innovation system; notably "Sectoral Systems of Innovation and Production in an Open Transition Economy (OTKA, contract No. T 046880 KGJ), Micro-Dyn (EU RTD FP6, contract No. 028868 CIT4), and AEGIS (EU RTD FP7, grant agreement No. 225134). Financial support provided by these projects is gratefully acknowledged.

[1] Several foreign firms have integrated their Hungarian partners into international production and innovation networks by diffusing their technological and organisational innovations, as well as by setting high standards in terms of performance and quality of products. Hence, certain 'archipelagos' of the Hungarian NIS are created/ strengthened this way.

[2] For a detailed discussion on the major players of the Hungarian NIS, see, e.g. Havas and Nyiri (eds) [2007], OECD [2008].

business-academia collaboration in Hungary, drawn by using several "lenses" offered by various data sets, together with findings of interviews conducted with firms.

1.2 State of the art

As already stressed, both the systems of innovation literature and the triple helix concept argue that the overall performance of innovation systems – be they sectoral, regional, or national – more depends on the type, intensity and quality of linkages and co-operation among the actors than on the performance of the individual organisations, of which a given system is comprised. (Bergek *et al.* [2008]; Carlsson *et al*. [2002]; Ergas [1986], [1987]; Etzkowitz, Leydesdorff [2000]; Edquist (ed.) [1997]; Fagerberg *et al.* (eds) [2005]; Foray (ed.) [2009]; Freeman [1987], [1991], [1994], [1995], [2002]; Lundvall (ed.) [1992], Lundvall *et al.* [2002]; Nelson [1993], [1995]; Niosi [2002]; Smith [2000], [2002]) Of these co-operations, business-university collaborations have been extensively studied in many countries, including Hungary. (Balconi *et al.* [2004]; Bonaccorsi *et al.* [2012]; Borsi [2005]; Carlsson [2012]; Cowan [2005]; D'Este, Patel [2007]; D'Este *et al.* [2011]; Feller *et al.* [2002]; Havas [2004], [2009] [2010], [2011]; Howels, Nedeva [2003]; Inzelt [2004], [2010]; Inzelt *et al.* [2011]; Jensen *et al.* [2010]; Laredo [2007, [2011]; Laursen, Salter [2004]; Mansfield, Lee [1996]; Mazzoleni, Nelson [2007]; Meyer-Kramer, Schmoch [1998]; Mohnen, Hoareau [2002]; Mora-Valentin *et al.* [2004]; Mosoniné Fried, Szunyogh [2008]; OECD [2001], [2002], [2008]; Pavitt [1999]; Rietzen, Soete [2011]; Rosenberg, Nelson [1994]; Schartinger *et al.* [2002]; Technopolis [2012])

1.3 Methodology

The papers cited above take many different angles, and use various sources and types of information (e.g. patent statistics, CIS [Community Innovation Survey] data, evidence from surveys, interviews, or case studies), but usually a given paper is relying on a single method, tackling one or two major research questions. In contrast, the proposed paper tackles both R&D and innovation collaborations among businesses and academia, by integrating information from different statistics, namely those on i) sources of funding for publicly financed R&D units (separating universities and other public R&D organisations), ii) sources of information for innovations, as well as iii) occurrence and 'value' of innovation co-operation by co-operation partners (from CIS and Innovation Union Survey). Further, it also relies on interviews to explore motivations and major features of business-academia co-operation.

The paper is organised as follows. *Findings and their interpretation* are reported in Sections 2-3. Section 2 first briefly describes the major players of the Hungarian NIS, and the ways in which they can collaborate, and then analyses business-academia co-operation from several angles in international comparison, relying on various types of statistics. Section 3, based on interviews with firms, argues that different types of firms have different types of needs, and given these reasons they enter into different types business-academia co-operation. Further, businesses and academic organisations have different motivations for co-operation, as well as different norms, values, and internal decision-making methods and systems, and thus co-operation is far from being smooth. Drawing on these discussions, *conclusions, policy implications and directions for further research* are summarised in Section 4. One of the major conclusions is that mapping business-academia collaborations by using multiple methods and multiple sources of information can significantly improve the reliability and richness of our understanding, and can offer insights on dynamics and qualitative features (e.g. motivations, incentives, strategic considerations) of these co-operation processes. As to policy implications, more refined policy measures are needed to promote business-academia collaboration in a more effective way, better tuned to the needs of the actors, based on a relevant taxonomy of RTDI collaborations.

2 Main actors of the Hungarian innovation system and their co-operation

2.1 Basic data

Hungary, with its population of 9.99 million (2% of the EU27 total) is a medium-sized EU member state. Its GDP was 0.7% of the EU27 total in 2011. As for economic development, measured by GDP per capita (in PPS), the country ranked 22-23rd with Lithuania in the EU27 in 2011, with 66% of the EU27 average.

The Hungarian GERD was fluctuating between 0.9-1.17% of the GDP in 2001-2010, then reached 1.21% in 2011. With these efforts, Hungary still devotes significantly fewer resources to R&D than the EU27 average: the Hungarian GERD/GDP ratio was 59.6% of the EU27 average in 2011. The share of FTE researchers in total employment increased from 0.38% in 2001 to 0.60% in 2011, while the share of all FTE R&D employees did so from 0.59% to 0.89% in the same period. The share of R&D investments in total investments grew from 0.76% in 2001 to 0.88% in 2011 (fluctuating between 0.60% and 0.90% in that period).

As for scientific output, the number of books and book chapters by Hungarian researchers increased by 9.6% in 2011 (the ones published in Hungarian by 6%, while that of published in foreign languages by 19.3%). The total number of articles increased by 0.8%, but that of published in foreign languages did so by 0.4%. There are significant differences by sectors: higher education staff members are the most productive (on average 120 books and book chapters as well as 346 articles by 100 FTE researchers), followed by researchers employed in the government sector (60 books and book chapters as well as 138 articles by 100 FTE researchers), and researchers working for businesses (2 books and book chapters as well as 12 articles by 100 FTE researchers). (KSH [2012], Table 24)

Most books, book chapters and articles in Hungarian language are published by social sciences and humanities researchers (57.5%), followed by technical, natural, and medical scientists (12.0%, 11.8% and 11.7%, respectively). Different pattern can be observed concerning books, book chapters and articles published in foreign languages. In this respect, natural scientists have a clear lead with 40.5% of total, followed by medical scientists (26.0%). (KSH [2012], Table 25) Hungarian scientific output ranked 35 in terms of publications recorded in Scopus in 1996-2007, and 24 in terms of citations in the same period. Researchers working in physics and astronomy; pharmacology, toxicology and pharmaceutics; earth and planetary sciences; and chemical engineering outperformed the Hungarian average both in terms of share of Hungarian publications in total publications, and the number of citations relative to the world average of citations in a given research field. (Schubert [2009])

As for more application-oriented outputs, 660 domestic patents were filed at the Hungarian Patent Office in 2011. The number of domestic trademark applications grew by 8.5%, reaching 3,772, the highest figure since 2004. In contrast, the number of patent applications filed abroad by Hungarian applicants decreased by 17% (142) in case of applications filed under the Patent Co-operation Treaty (PCT), and by 12% for European patents (168). The number of WIPO international trademark applications increased by 40%. (HIPO [2012], p.14)

Hungary is one of the moderate innovators in the EU with a below average performance: her Summary Innovation Index was around 0.301-0.335 in 2008-2012 (0.323 in 2012), as opposed to the EU27 average fluctuating between 0.504-0.544 in the same years. (IUS [2013]) The share of innovative enterprises has been particularly low since 1999-2001: 23.3%, 20.9%, 20.1%, 20.8%, and 18.4%, respectively. (CIS3, CIS4, CIS2006, CIS2008, CIS2010)

2.2 The principal research performer sectors

The number of (FTE) researchers employed by *businesses* has been steadily increasing since the mid-1990s (and particularly rapidly since 2004), reaching 11,773 in 2011, compared to 3,901 in 2000.[3] This sector has been the largest employer of (FTE) researchers since 2006. The share of business enterprise researchers in the national total was 51.1% in 2011 (up from 27.8% in 2001).

[3] Data used in this sub-section are taken from the Central Statistical Office and Eurstat, own calculations are also based on these data.

This ratio, however, is around 60-70% in the advanced economies, and well above 50% in several other countries. The Hungarian figure, however, was above the EU27 average: 45.1% in 2010.

The number of business R&D units rose from 478 in 2000 to 1,432 in 2011. Compared to the total number of active firms (at around 300,000), this is still a very small number, in spite of the impressive growth (nearly 3-fold increase). These R&D units with their average size of 8.2 FTE researchers are larger than the R&D units operated at universities (4.3 FTE researchers), but significantly smaller than PROs (28.0 FTE researchers). (Median size of research units operating in different sectors is not available.)

Business R&D expenditures (BERD) have increased significantly both in absolute and relative terms: from €219.7m in 2001 to €752.0m in 2011 (current prices), and thus amounted to 0.75% of the GDP in 2011 (up from 0.37% in 2001), but stayed way below the EU27 average: 1.26% in 2011. The share of GERD performed by the business enterprise sector was 62.4% in 2011, same as the EU27 average. The R&D expenditures of businesses are heavily skewed: large enterprises (i.e. those with at least 250 employees) accounted for 56.4% of BERD in 2011, but their weight had been even higher, that is, two-thirds of BERD in 2008, and 70-80% in 2000-2007.

Higher education (HE) organisations had employed 5,975 FTE researchers in 2011, that is, 26.0% of the national total. The share of GERD performed by the HE sector is significantly lower: it fluctuated between 24.0% and 26.7% in 2000-2006, then dropped every single year in 2007-2010, reaching 19.9%, and increased slightly in 2011 (20.2%), while the EU27 average was 24.2% in 2010. Among the three major RTDI performing sectors, the highest number of R&D units was located at tertiary education organisations until 2010 (1,409 out of 2,983), but this number dropped to 1,380 in 2011, and thus businesses took the lead in this respect, too. R&D expenditures in the HE sector (HERD) have more than doubled in absolute terms: from €97.3m in 2000 to €243.1m in 2011 (current prices). HERD amounted to 0.24% of the GDP – half of the EU27 average: 0.49% – in 2011.

The number of *publicly financed R&D organisations* (PROs) was 188 in 2011. Compared to the total number of R&D units, that is, 3,000, this is a relatively low figure. This sector became the smallest one in terms of employment already in 2005. The sector employed 5,271 (FTE) researchers in 2011, that is, 22.9% of all (FTE) researchers. (This share at its peak was 44.2% in 1996.) Despite the declining trend, the weight of PROs is still high in international comparison: the EU27 average was 12.4% in 2011. The share of GERD performed by PROs also declined heavily: from its peak reached in 2002, that is, 32.9% to 15.8% in 2011, but it is still above the EU27 average (12.9% in 2010).

In sum, the structure of the Hungarian R&D sub-system – in terms of the weight of R&D performers – has changed significantly in the space of 10-12 years, and now resembles the one in advanced market economies (that could be proxied either by the EU27 or OECD average). Yet, Hungarian R&D efforts are way below those of the advanced countries (in terms of GERD/GDP or the share of researchers in total employment), and Hungary is not an advanced market economy, either. (Table 1)

Table 1: R&D inputs and the weight of R&D performing sectors, Hungary and the EU27, 2001 and 2011 (per cent)

	2001	2011
GERD/GDP Hungary	0.93	1.21
GERD/GDP EU27 average	1.87	2.03
Share of researchers (FTE) in total employment Hungary	0.38	0.60
Share of researchers (FTE) in total employment EU27 average	0.55	0.74
Business sector		
BERD/GERD Hungary	40.09	62.42
BERD/GERD EU27 average	64.65	62.35
Share of business researchers (FTE) Hungary	27.76	51.14
Share of business researchers (FTE) EU27 average	46.93	45.11
Higher education sector		
HERD/GERD Hungary	25.74	20.18
HERD/GERD EU27 average	21.44	24.23*
Share of HE researchers (FTE) Hungary	40.49	25.96
Share of HE researchers (FTE) EU27 average	37.83	41.32
Government sector		
GOVERD/GERD Hungary	25.88	15.76
GOVERD/GERD EU27 average	13.14	12.86*
Share of government researchers (FTE) Hungary	31.75	22.90
Share of government researchers (FTE) EU27 average	14.16	12.40

Source: author's calculation based on Eurostat data, and CSO

* 2010 data

Note: The Hungarian BERD+HERD+GOVERD amounts to only 91.72% of GERD in 2001, while 98.36% in 2011. These sums are 99.23% and 98.95% for the EU27 average in 2001 and 2010, respectively.

2.3 The weight of business resources in funding R&D activities

BERD is mainly financed by the own resources of businesses: this share was 75.7% in 2001, and then decreased to 69.5-71.0% in 2009-2011. From a different angle, the bulk of business R&D funds is devoted to intra-mural R&D activities: 87.6-91.4% in 2009-2011. It worth stressing, though, that businesses fund research activities both at HE institutes and in the government sector (publicly financed R&D institutes, or PROs) to a noteworthy extent.

Hence, a closer look at the sources of Hungarian R&D expenditures indicates improving co-operation among the research actors. While only 4-5% of the total HERD had been financed by firms in 2000-2001, this ratio jumped to 11-13% in 2002-2006, further increased in 2007-2010, reaching 15.5% in 2009, and 13.6% in 2010, and then dropped to 11.3% in 2001. This is much higher than the EU27 average (fluctuating between 6.2-6.7% in 2000-2010). There are is a single OECD member country with higher shares, namely Turkey (14.6.-23.8% in 2005-2011), and a three others with similar ones, that is, Germany (14.0-15.5% in 2005-2010), Japan (11.0-15.2% in 2005-2011), Slovenia (9.0-12.5% in 2005-2011). This high ratio of business funding might be attributed to the low level of the Hungarian HERD in absolute terms (€141-243m a year in 2001-2011, current prices): a few projects commissioned by firms, amounting to relatively small funds by international standards, can lead to a high weight of business funding in HERD.

The financial links between firms and publicly financed R&D institutes show a more varied picture in recent years: the share of firms in Government Intramural Expenditure on R&D (GOVERD) was 11-13% in 2000-2001, dropped by around 50% in 2002-2004, and then exceeded 10% again in 2005. Since 2006 this indicator has been in the range of 11.5-14.3% (11.5% in 2011). These variations hint to a more general hypothesis: incentives provided by various policy tools are just one element of a bigger, more complex system influencing the innovation behaviour of firms, especially their RTDI co-operation with other domestic actors.

The share of GOVERD financed by industry is higher in Hungary than either the OECD or the EU27 average (2.8-3.8% in 2001-2010; and 5.5-9.0% in 2001-2010, respectively). Yet, it is below the Dutch, and NZ level, while similar to the Finnish, and Slovak and Slovene data. (OECD MSTI) Still, it is a good position in international comparison. The low volume of the Hungarian GOVERD (€142-248m a year in 2001-2011, current prices), most likely, is an important factor in explaining this ranking, just as in the case of a relatively high share of business funding in HERD.

2.4 Information sources for innovation – as assessed by firms

The quality of co-operation among the NIS players can also be characterised by firms' assessments as to the importance of sources of information for their innovation activities. For very large share of Hungarian firms the most important source of information for innovation is their own enterprise or enterprise group (above 50% both in 2006-2008 and 2008-2010). Other firms, with which they are in regular contact, are also frequently mentioned: clients (38.0% in 2008-2010); suppliers (27.3%); competitors (22.2%) since 1999-2001. *Government or public research institutes* are at the bottom of the list, while *higher education institutes* have taken over journals and technical publications and professional and industry associations only since 2004-2006. (Table 2)

Table 2: Highly important sources of information for product and process innovation, Hungary (100 = enterprises engaged in product and/or process innovations)

	1999-2001	2002-2004	2004-2006	2006-2008	2008-2010
Within the enterprise	64.0	41.7	40.5	50.3	50.4
Within the enterprise group	5.6				
Clients or customers	72.0	28.2	33.9	39.0	38.0
Suppliers of equipment, materials, components or software	33.2	23.4	21.5	26.3	27.3
Competitors or other enterprises of the same sector	47.5	17.7	19.8	20.9	22.2
Conferences, trade fairs, exhibitions[a]	32.4	12.6	13.1	12.7	14.4
Consultants, commercial labs or private R&D institutes	–	6.5	9.3	15.0	12.8
Universities or other higher education institutes	*6.3*	*4.7*	*7.6*	*10.2*	*10.8*
Scientific journals and trade/technical publications[b]	25.9	9.9	7.4	8.1	9.3
Professional and industry associations	–	5.5	4.2	6.1	6.9
Government or public research institutes	*8.6*	*1.2*	*2.4*	*4.2*	*4.4*

Sources: Eurostat, various rounds of CIS
[a] In the 1999-2001 questionnaire this category was called "Fairs, exhibitions".
[b] In the 1999-2001 questionnaire this category was called "Professional conferences, meetings, journals"

As for international comparison, a similar picture can be observed by taking both CIS2008 and CIS2010 data for the participating countries: in all these countries the largest share of firms regards their own enterprise or enterprise group as a highly important source of information for innovation, and other firms – suppliers, customers, competitors and commercial labs are also highly appreciated by a large part of firms. Thus Figure 1 only presents these business-type sources of information. The other sources – which can be called 'scientific' ones in a bit simplified way – are depicted on Figure 2. These are "highly important sources of information" for a significantly lower share of innovative firms. In most countries conferences, trade fairs, and exhibitions ranked first in this group, scientific journals and trade/technical publications comes second, followed by universities and public research institutes. Hungarian universities, in contrast, ranked second as they had by far the highest appreciation compared to those in the other EU countries.[4]

2.5 Frequency of innovation co-operation and firms' assessment of co-operation methods

As for innovation co-operation partners, Hungarian firms have changed their preference by the late 2000s, when suppliers were mentioned most frequently (27.9%), followed by universities (21.4%), consultants and commercial labs (21.3%), customers (20.6%), competitors (17.0%), other firms in their enterprise groups (13.7%), and public R&D institutes (10.2%). The frequency of innovative firms' co-operation with higher education organisations first declined significantly (from 21.6% in

[4] Besides EU members, Norway and Croatia also took part in CIS2010.

1999-2001 to 13.7% in 2002-2004), and then improved (18.0% in 2004-2006; 18.7% in 2006-2008), in essence reaching the 1999-2001 level again in 2008-2010. As for their co-operation with PROs, it is significantly less frequent, but 2008-2010 also saw an important improvement. (Table 3)

Table 3: Share of innovative enterprises indicating co-operation with specified partners, Hungary, 1999-2010 (percentage of all innovative enterprises)

	1999-2001	2002-2004	2004-2006	2006-2008	2008-2010
Other enterprises within the enterprise group	5.1	10.1	8.3	11.8	13.7
Suppliers of equipment, materials, components, or software	26.8	26.2	25.5	27.5	27.9
Clients or customers	24.8	19.6	16.2	18.6	20.6
Competitors or other enterprises in sector	10.9	13.6	12.1	13.1	17.0
Consultants*	14.6	12.6	15.3	16.6	21.3
Private R&D organisations	13.7				
Higher education organisations	*21.6*	*13.7*	*18.0*	*18.7*	*21.4*
Government or public research institutes	*8.6*	*4.9*	*6.1*	*6.5*	*10.2*

Sources: 1999-2001: KSH, for the later periods: Eurostat
* Co-operation with consultants and private R&D organisations has been merged since the 2002-2004 survey

Table 4 compares 2008-2010 innovation co-operation data for nine EU members: six new member states (Czech Republic, Hungary, Poland, Romania, Slovakia, and Slovenia), two so-called cohesion countries (Ireland and Portugal), and one of the richest country, that is, Austria. The frequency of co-operation with universities was almost at the same level in Austria, Slovenia, and Hungary, fairly above the Czech, Slovak, Polish, Irish, Portuguese, and Romanian data (listed in the order of the occurrence of business-university co-operation for innovation). As for co-operation with PROs, Slovenia is in a different 'league' with a fairly high frequency, separated by a wide gap from Poland, while the other six countries, for which there are data, constitute a third group with almost negligible figures. (Table 4)

Table 4: Share of innovative enterprises indicating co-operation with specified partners, selected EU countries, 2008-2010 (percentage of all innovative enterprises)

	AT	CZ	HU	IE	PL	PT	RO	SK	SL
Other enterprises within the enterprise group	22.4	15.3	13.7	14.7	11.6	6.5	2.7	19.2	13.5
Suppliers of equipment, materials, components, or software	27.3	23.9	27.9	16.1	23.2	14.0	14.4	32.2	29.9
Clients or customers	22.1	19.2	20.6	14.9	13.8	12.4	10.9	27.5	27.1
Competitors or other enterprises in sector	11.0	10.8	17.0	4.9	7.8	6.3	6.6	22.3	13.4
Consultants, commercial labs,	18.7	12.3	21.3	11.3	10.4	8.3	6.3	15.1	22.0
or private R&D organisations	21.8	14.6	21.4	9.8	10.8	8.3	6.4	13.6	22.0
Higher education organisations	9.2	6.9	10.2	7.1	7.7	5.1	3.6	9.1	14.3
Government or public research institutes	1.2	0.6	1.0	..	3.3	0.6	0.4	0.4	13.7

Sources: Eurostat

When analysing business-academia co-operation it is also important to note which co-operation method is the most valuable one for firms. In Hungary co-operation with suppliers and universities are mentioned as the most valuable method by the largest share of firms (11.2%, and 8.5%, respectively), followed by other enterprises within the enterprise group (6.5%), consultants, commercial labs, or private R&D institutes (6.2%), and customers (5.8%). In most other countries, participating in CIS2010, co-operation with suppliers, customers, and other enterprises within the enterprise group is mentioned by a relatively large portion of firms as the most valuable method. (Figure 3)

As for the frequency of innovation co-operation between business and higher education institutes, Hungary was ranked four in 2008-2010 (CIS2010) – up from her 5th position in 2006-2008 –, and universities had a higher appreciation only by Slovene firms (21.2% of them perceived this one as the most valuable co-operation method), that is, Hungarian universities are ranked second in this respect. (Figure 4)

Taking the frequency of innovation co-operation between business and PROs, Hungary was ranked six (up her 16th position in 2006-2008). Again, Slovene firms gave the highest appreciation to PROs: 13.7% of them said that this was the most valuable method for innovation co-operation, while this ratio was 4.4% in Norway, 4.3% in Spain, around 2% in Belgium, Lithuania, and Germany, and around 1% in eight countries, including Hungary, and below 0.65% in seven other countries. (Figure 5)

3 FIRMS' MOTIVATIONS FOR R&D AND INNOVATION CO-OPERATION

It has been a recurring theme of various reports and policy documents that the intensity, frequency, and quality of business-academia co-operation in Hungary has been significantly below the desired level. (Arnold et al. [2007]) The SME development strategy of the Ministry for Economy and Transport has stressed that knowledge diffusion between publicly financed research institutes and business has been insufficient; directors of PROs have not considered businesses' interests when defining research themes or assessing researchers' performance; researchers' mobility between PROs and businesses has hardly occurred. (GKM [2008], p. 34)

Thus several Hungarian science, technology, and innovation (STI) policy measures have been devised with the aim of promoting business-academia co-operation in Hungary, either by making this type of collaboration compulsory, or giving priority to joint project proposals of firms and universities or PROs.[5] Most likely these measures have at least some impacts: the frequency of business-academia collaboration has increased to a noteworthy extent since 2002. (Table 3) An evaluation report on the use of the Research and Technological Innovation Fund – the most important domestic fund to support RTDI activities – in 2004-2009 also states that "The corporate sector and […] universities/ public research institut[e]s have definitely come closer to one another." (Ernst & Young and GKI [2010a], p. 4)

Interviews conducted in three sectors – automotive, pharmaceuticals, and software development – have confirmed that companies and public R&D units (PROs) are driven by fundamentally different incentives and goals to be involved in R&D and innovation activities. Hence, there are inherent hindrances to business-academia collaboration – one of the weak points of the Hungarian national innovation system, highlighted by various analyses. In brief, companies are interested in a relatively wide array of R&D activities (from day-to-day problem solving to long-term strategic research, some of which may require to produce advanced scientific and technological knowledge, or even path-breaking new theoretical results), but those should lead to business results (e.g. enhanced productivity, larger market shares, entry to new markets, increased profits). Projects are regularly monitored and assessed, and when necessary, a given project could be substantially reshaped (the number participants, R&D methods applied, budget, etc.), or even stopped. Thus, tight project management (meeting deadlines and 'respecting' budget constraints) and keeping commercially sensible information secret are of vital importance. In contrast, researchers working for universities and PROS units are not only interested, but even forced to disclose their results as

[5] The first of these types of measures were introduced already in the second half of the 1990s. For a broad overview of these measures see, e.g. Havas and Nyiri (eds) [2007], and for more details the annual ERAWATCH and TrendChart country reports, as well as the Joint Inventory of Policy Measures by ERAWATCH and TrendChart at http://erawatch.jrc.ec.europa.eu/erawatch/opencms/research_and_innovation/

quickly and as widely as possible, given the evaluation criteria applied in the academic world. Further, they are usually less accustomed to tight project management, but noticeable changes are occurring in this respect, due to tighter control exercised by both the domestic and foreign funding agencies.

These systemic hindrances to business-academia collaborations – different goals and incentives for academic researchers and businesses – are not a unique feature of Hungarian innovation system. Several "profound differences in the 'scientific' and 'industrial' cultures" – fairly similar ones to those observed in Hungary – have been highlighted in a recent presentation by the General Secretary of the European Council of Academies of Applied Sciences, Technologies and Engineering. (Lukasik [2013]

Based on the interviews, at least three fundamentally different types of business-academia collaboration can be identified. No doubt, other types of co-operations might also be found, and a more detailed, more refined classification could also be devised. The current typology considers two major aspects: weather there is an ownership link between the partners, and the main objectives of co-operation.

1) Co-operation between R&D intensive spin-off companies and their founding university or PRO

Research-intensive spin-off firms naturally co-operate closely with those research units where their co-founders used to work (or still keep a part-time position). In spite of strong personal contacts, certain frictions might hinder co-operation in these cases, too, given the rigid structures and slow, cumbersome decision-making processes at the public research institutes. These tensions can be further aggravated when the founding university/ PRO is constrained either by regulations or its internal rules and norms in considering the business interests of the spin-off firms, and in finding a common ground between academic and business cultures. The goals and nature of RTDI co-operation between these types partners are driven by the business opportunities of the spin-off firm (what research capacities of the university/ PRO – including human resources – can be rented/ hired for joint projects).

2) Co-operation aimed at solving short-term, relatively simple technical problems

Most companies, even those using fairly basic production technologies, regularly face technical problems: a new material or component/ sub-system should be used, given an incremental innovation (an existing product is modified), or a new supplier; production costs should be reduced, products and/ or production processes/ methods should be improved at the request of their clients, and thus new equipment should be added to the existing production lines, etc. Large companies tend to rely on their internal resources to tackle these tasks. Small and medium-sized firms, however, are likely to seek external assistance, usually universities or colleges located nearby. There is an even stronger incentive to co-operate when a scheme can be identified, offering financial support to solve technical problems (which need to be solved in any case), in a collaborative way (which is necessary anyway, given the lack of in-house technical expertise).

3) Strategic, long-term R&D and innovation co-operation

Larger firms, relying on knowledge-intensive activities to maintain their competitive edge, are more interested in co-operating with universities and PROs on strategic, long-term R&D projects to explore new technological opportunities, or breaking new grounds. In these cases firms can benefit from collaborating academic researchers possessing advanced S&T knowledge, embedded in international networks, and thus having access to an even wider pool of knowledge. By sharing tasks and knowledge, firms can reduce both the costs and scientific uncertainties. Moreover, several domestic and EU schemes promote these types of co-operations, further reducing costs.

As part of these long-term, strategic collaboration, firms also support PhD courses financially and/or offering PhD students relevant themes (projects) for their thesis. Besides the S&T results achieved by these projects, a major advantage for firms is that they can collect direct experience as to how these students work – solve problems, communicate and co-operate with team members, take the pressures from deadlines, inevitable failures, tensions with colleagues, etc. – and thus can make a better substantiated decision as to whom to employ, as opposed to the case when they can only rely on a few documents and one or two interviews.

A broader form of co-operation is supporting tertiary education by donating modern equipment to universities. In that way firms can make sure that the next generation of engineers and scientists would be familiar e.g. with up-to-date measurement techniques and experienced in using other relevant instruments, which might not be available at universities without these co-operations.

This type of co-operation – and thus at least some of the elements/ tools mentioned above – can be of relevance for those medium-sized companies, too, for which gaining access to advanced S&T knowledge and new talents is of crucial importance.

This tentative typology can – and should – be developed into a more detailed taxonomy. Depending on the objectives of further analyses, the following aspects can be used when refining the current typology: the objectives, organisational form and duration of co-operation; types of participants (domestic vs. foreign universities and firms); major characteristics of the business participants (size, ownership, specific sectoral/ technological/ strategic features, etc.)

Even this tentative typology is sufficient to stress that different firms are faced with different needs, and thus pursue different RTDI strategies. Hence, different forms and types of business-academia co-operation can be observed, with specific goals and activities. STI policies, however, tend to neglect this diversity, and not only in Hungary.

4 CONCLUSIONS, METHODOLOGICAL AND POLICY IMPLICATIONS

Mapping co-operation among the actors of innovations systems is in a forefront of the interests of analysts and policy-makers in many countries. One of the major lessons of innovation studies has been that different types of knowledge, skills and experience are required for successful innovation processes, and these elements are rarely possessed by single entities; rather, these are distributed among various actors. Hence, their co-operation is vital to integrate these elements to exploit them for economic and social ends.

Taking these observations as its starting points this paper has mapped business-academia collaborations in Hungary by using various sets of statistics, as well as interviews. Firms in Hungary contribute to the R&D funds used by universities and PROs to a significant extent. For both of these research performing sectors, business funding in Hungary is markedly higher than the EU27 or OECD average. As for sources of information for innovations, universities and PROs are less important for Hungarian firms than other firms in their enterprise groups, customers, suppliers, competitors and/or other firms in the same sector. CIS data show a fairly similar pattern in all EU countries. In Hungary, however, universities are more important sources for information than PROs, and the degree of their importance has significantly increased since the late 1990s. As to innovation co-operation, universities have become the second most frequently chosen partners of Hungarian firms by 2010, and Hungarian universities had the second highest appreciation compared to those in the other EU countries.

Interviews have also been used to shed light on the dynamics and qualitative features (e.g. motivations, incentives, strategic considerations) of business-academia co-operation processes. Thus mapping these collaborations by using multiple methods and multiple sources of information can significantly improve the reliability and richness of our understanding, leading to both theoretical results (e.g. a taxonomy of business-university co-operations) and more effective STI policies.

This research has confirmed that (i) motivations, incentives for, and norms of, conducting RTDI activities diametrically differ in business and academia (higher education and PROs); and (b) different types of firms have different needs. Thus, more refined policy measures are to be devised to promote business-academia collaboration, better tuned to the needs of the actors, based on a relevant taxonomy of RTDI collaborations.

Further, evaluation criteria for academics should also be revised to remove some major obstacles, currently blocking more effective business-academia co-operation. Obviously, it would require sound analyses of a given higher education system, and then a thorough decision-preparatory process because quite naturally a fierce opposition is likely to arise from academics, given strong traditions at universities and PROs.

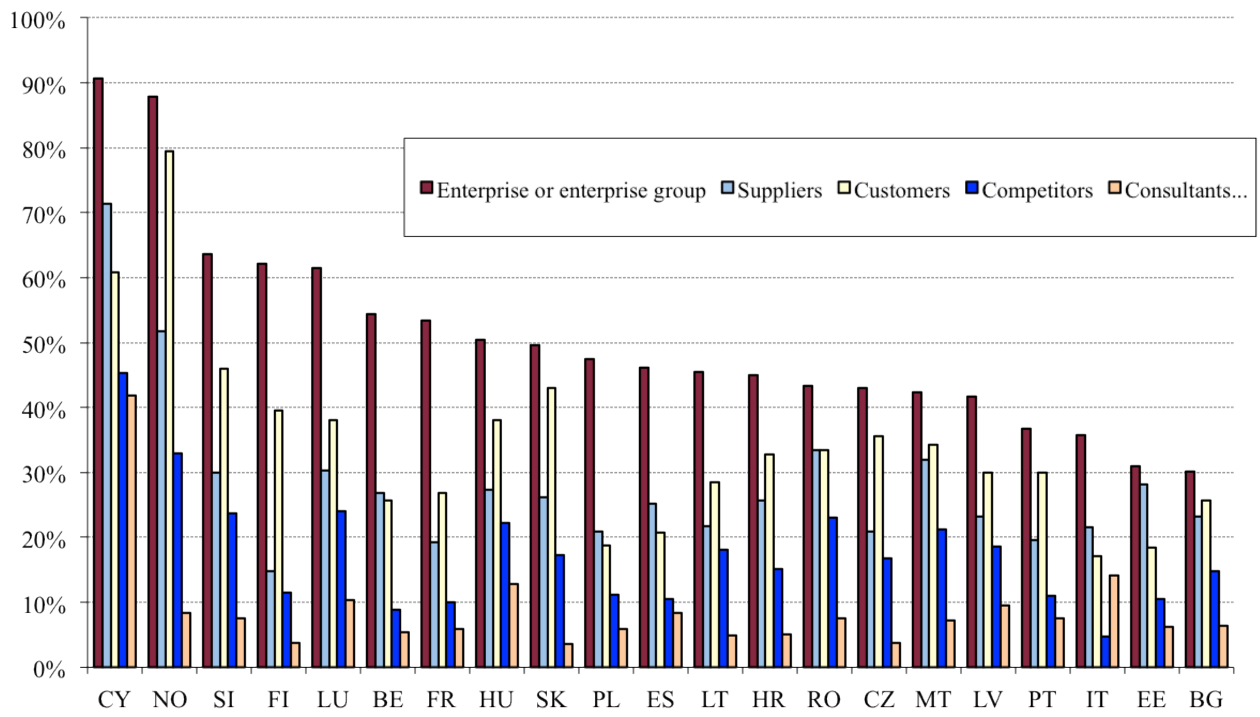
Interviews also suggest that in some cases collaborative projects had already been decided; i.e. an available support scheme has not oriented the RTDI activities of a given firm. Moreover, most of these projects would have been conducted without public support, too. In other words, additionality in the narrow sense has been fairly low. More detailed case studies would be needed to establish if additionality in the broader sense – the so-called behavioural additionality – has occurred in any of these cases. (Lipsey and Carlaw [1998]; OECD [2006])

It should be also stressed that consultancy firms specialising in identifying opportunities to obtain public support and drafting project proposals have played a major role in several cases. Without them a number of firms would have not applied for public support. Again, more thorough research, relying on a larger sample, would be needed to draw firm policy conclusions. So far, only diametrically opposite interpretations can be put forward as hypotheses. A) These consultancy firms play a useful role in 're-wiring' and revitalising the Hungarian NIS: they disseminate vital information and build contacts among the interested players more efficiently than the responsible government agencies and other public (non-profit) organisations charged with these tasks. B) These consultancy firms pursue a special rent-seeking strategy, and appropriate some 10-15% of public funds meant to be used for advancing good causes (for the whole society).

Both the methodological and policy implications could be generalised beyond the case of Hungary, with the actual research design and the detailed policy recommendations tailored to the innovation systems in question.

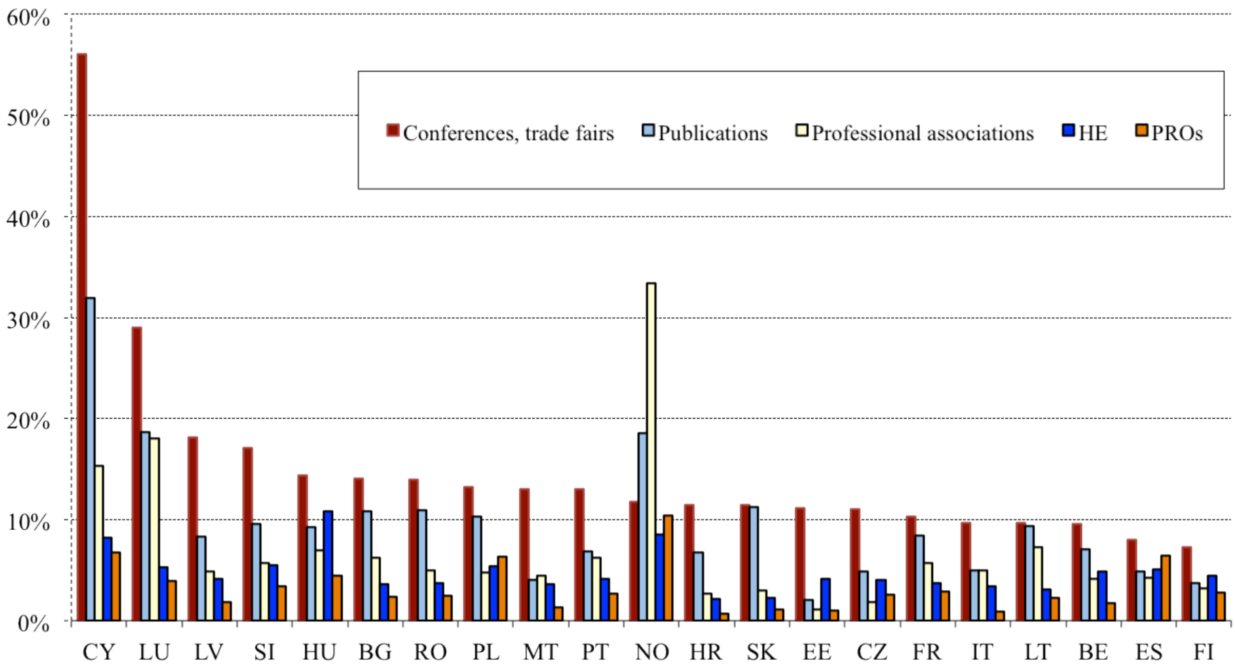
FIGURES

Figure 1: Highly important 'business' sources of information for product and process innovation, EU members, Croatia, and Norway, 2008-2010



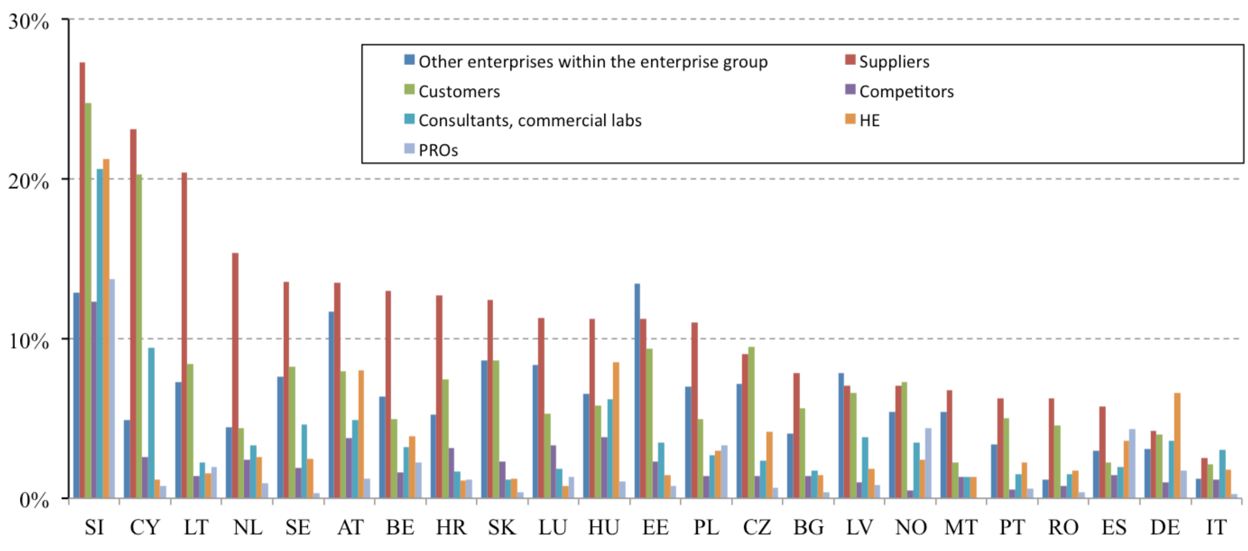
Source: Eurostat, CIS2010

Figure 2: Highly important 'scientific' sources of information for product and process innovation, EU members, Croatia, and Norway, 2008-2010



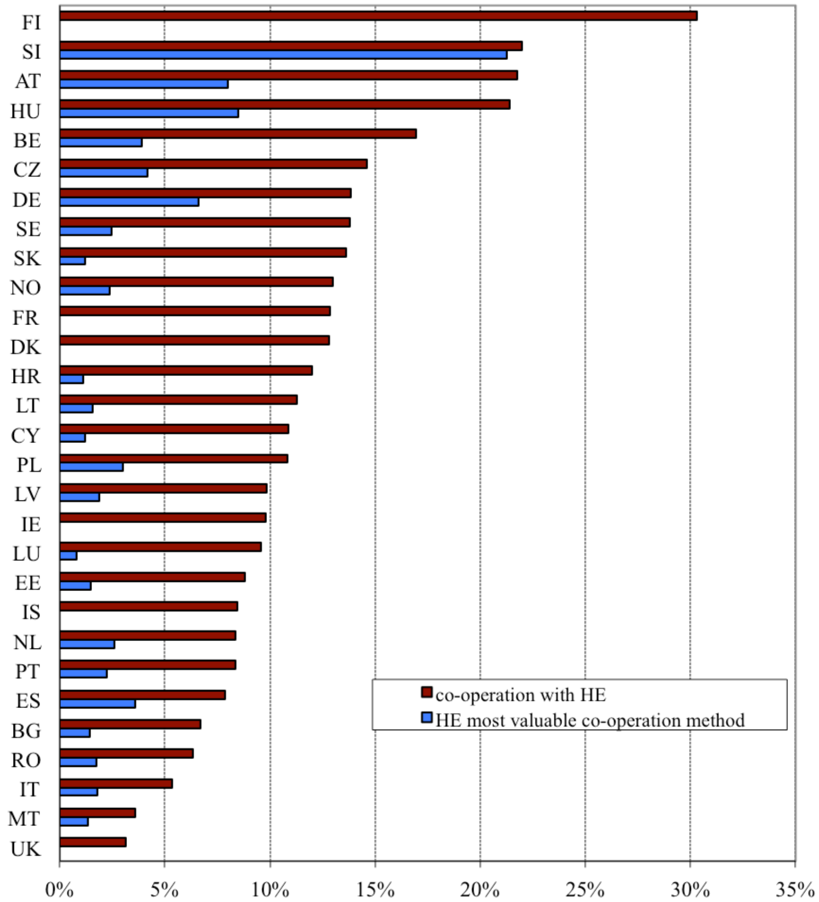
Source: Eurostat, CIS2010

Figure 3: Most valuable innovation co-operation, EU members, Croatia, and Norway, 2008-2010



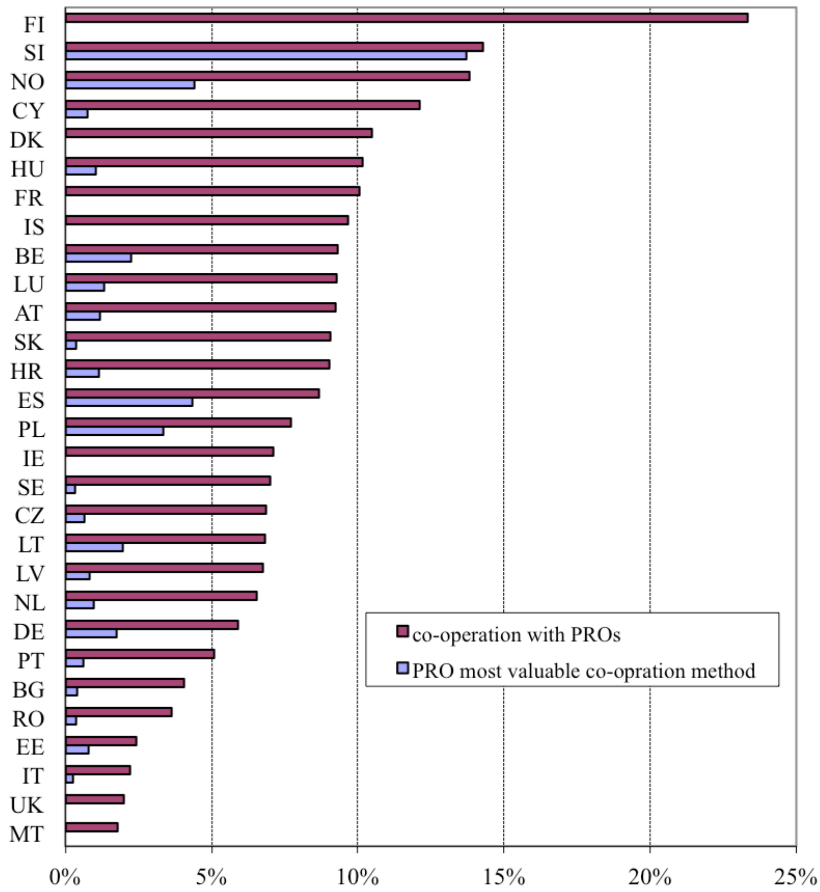
Source: Eurostat, CIS2010

Figure 4: Innovation co-operation with higher education institutes, EU members, Croatia, and Norway, 2008-2010



Source: Eurostat, CIS2010

Figure 5: Innovation co-operation with PROs, EU members, Croatia, and Norway, 2008-2010



Source: Eurostat, CIS2010

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