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Comparative analysis of policy-mixes of research and innovation policies in Central and Eastern European countries

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Comparative analysis of policy-mixes of research and innovation policies in Central and Eastern European countries

Abstract

Observing the CEE members of the EU (EU10 countries) from a distance, they certainly used to share major structural similarities given their historical legacies, as well as certain 'unifying' effects of their transition to market economy and democracy. Yet, a closer look reveals important elements of diversity in (a) the structure of their national innovation system, (b) the direction of recent structural changes, (c) innovation performance, and (d) patterns of business-academia collaboration. Given this diversity one would assume that fairly different needs are identified in the EU10 countries, necessitating differentiated, 'tailored' policy responses. Yet, these countries follow the same STI policy rationale, namely the market failure argument, which itself can be seen as a unifying force. Actually, this is not unique to the EU10 countries: the science-push model of innovation is still highly influential in the STI policy circles both at the level of the EC and the member states, despite a rich set of research insights stressing the importance of non-R&D types of knowledge in innovation processes.

Content

1 Introduction[1]

The main aim of this GRINCOH report is to compare science, technology and innovation (STI) policy mixes of the 10 Central and Eastern European (CEE) member states of the European Union (henceforth: EU10 countries). Thus, several major questions are *not* analysed here: (i) the impacts of STI policies on innovation performance (whether the policy goals and tools have been appropriate, whether their implementation has been effective and efficient); (ii) the impacts of various other factors on innovation performance (in brief, the so-called framework conditions for innovation, which include, among others, macroeconomic conditions and stability, regulations on competition, the nature and intensity of competition, non-STI policies influencing innovation processes, entrepreneurial attitudes and behaviour, conditions for doing business); (iii) the contribution of innovation performance to economic performance[2] and quality of life (e.g. via enhanced productivity and improved competitiveness concerning the former, and better products and services, reduced environmental burden, concerning the latter); and (iv) the impacts of economic performance, and quality of life on innovation performance (e.g. via availability of resources generated by a healthy economy for RTDI activities and creativity thanks to a tolerant, vibrant, supportive society, given high quality of life). Any attempt to address just one of these questions would require 10 detailed country case studies, and that has been clearly beyond the means and scope of the GRINCOH project. Yet, what is presented in this paper still might be a relevant contribution when these broader questions are tackled.

As a background to the comparative analysis of the STI policy mixes pursued in the EU10 countries, first the analytical framework is presented briefly in Section 2 by summarising the various models of innovation and juxtaposing major economics paradigms focussing on their approach to innovation. The common theoretical framework underpinning the various analyses constituting the implementation of Task 7 of WP3 of the GRINCOH project is the evolutionary (and institutional) economics of innovation.[3] Then the structure of, and changes in, the national innovation systems (NIS) of these countries are described, namely the main actors in STI policy-making, as well as the R&D performing sectors. (Section 3) Needless to stress that the NIS (its actors and structure; the connections, information and financial flows between the actors; its formal and informal rules governing these interactions; as well as the strategies and the behaviour of various actors) plays an important role in devising STI policies. In turn, the NIS itself, and in certain periods its policy governance sub-system in particular, can be a subject of STI policy measures. Again, analysing these interplays between the NIS and STI policies would require very detailed, meticulous studies at a country level, and thus these questions cannot be addressed in a single paper.

Past (and future) innovation performance is also closely interlinked with STI policies, and thus the innovation performance of the EU10 countries is characterised in comparison with other EU countries – in some cases with the four ‘classic’ cohesion countries, in particular –, using some basic indicators, as well as two composite indicators in Section 4.[4] There are several further complex interrelations, in which

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[1] Comments on an earlier draft by Vladimir Balaz, Anda Adamsone-Fiskovica, Zoya Damianova, Radu Gheorghiu, Agne Paliokaite, Marek Tiits, Inga Ulnicane-Ozolina, and György Varga are gratefully acknowledged.

[2] Macroeconomic performance of the EU10 countries has been analysed by WP1 of the GRINCOH project; for a summary of the main results see Havlik (2015).

[3] More specific strands of the literature are highlighted in the relevant sections, and in more detail in Havas (2015b) and Izsak et al. (2014).

[4] Scientific performance of the EU10 countries is discussed in detail in other GRINCOH papers, especially Płoszaj and Olechnicka (2015), and Radošević and Yoruk (2013). Technology upgrading of the EU10 countries, exploring patent data, is thoroughly discussed in another GRINCOH paper by Jindra et al. (2015), while patenting activities of CEE countries (as a region) by Dominguez Lacasa and Giebler (2013).

innovation performance is an important element. These include: the impacts of economic performance on innovation performance, and the other way around; what STI policy needs and opportunities are perceived, given the economic and innovation performance; and what financial resources are available for supporting research, technological development and innovation (RTDI) activities via direct and indirect policy tools (e.g. subsidies and tax incentives). Again, most of these aspects are beyond the scope of the GRINCOH project.

The frequency and quality of business-academia collaborations are among the major factors influencing innovation performance. Thus various aspects of these collaborations are depicted by exploiting the available statistical data sets on R&D and innovation. (Section 5) These findings also shed light on the nature of innovation processes (what information sources and what co-operation methods for innovation are used by what proportion of firms, and how these sources and methods are assessed by them), and hence can be used to establish if STI policies are based on a satisfactorily accurate understanding of innovation processes.

That leads to the major subjects of Section 6, which first briefly recalls what STI policy rationales can be derived from major schools of economic thought. It is followed by a description of the STI policy rationale followed in the EU10 countries.[5]

The STI policy mixes applied in the EU countries are characterised by using cluster analysis techniques. (Section 7) The underlying question in that part of this report is whether countries at different levels of development and maturity of their innovation systems have devised different innovation policy mixes.[6] The theoretical and policy relevance of the findings emerging from these interconnected building blocks are discussed in the concluding section, where several policy recommendations are also presented.

2 Analytical framework

Various economics schools analyse innovation processes in rather dissenting ways: they rely on dissimilar postulates and assumptions, ask different research questions, and often use their own specific analytical tool and techniques. Moreover, these different schools of thought offer contrasting policy advice. Given the huge economic and societal impacts of innovation performance, it is of paramount importance how innovation is understood (defined), how it is measured and analysed by researchers, what types of goals are set and what tools are used by policy-makers. In brief, theory building, measurement and policy-making can interact either in a virtuous or a vicious circle.

This paper argues that those economic theories give a more accurate, more reliable account of innovation activities that follow a broad approach of innovation, that is, consider all knowledge-intensive activities leading to new products (gods or services), processes, business models, as well as new organisational and managerial solutions and techniques, and thus take into account various types, forms and sources of knowledge exploited for innovation by all sorts of actors in all economic sectors. In contrast, the narrow approach focuses on the so-called high-tech goods and sectors. The choice of indicators to measure innovation processes and assess performance is of vital significance, too: the broad approach is needed to collect data and other types of information, on which sound theories can be built and a reliable and comprehensive description of innovation activities can be offered to decision-makers. Finally, STI policies

[5] Sections 2-6 pull together the findings of two background papers written for WP3, Task 7 of the GRINCOH projects, namely Havas (2015a) and (2015b).

[6] Section 7 draws on Izsak et al (2014).

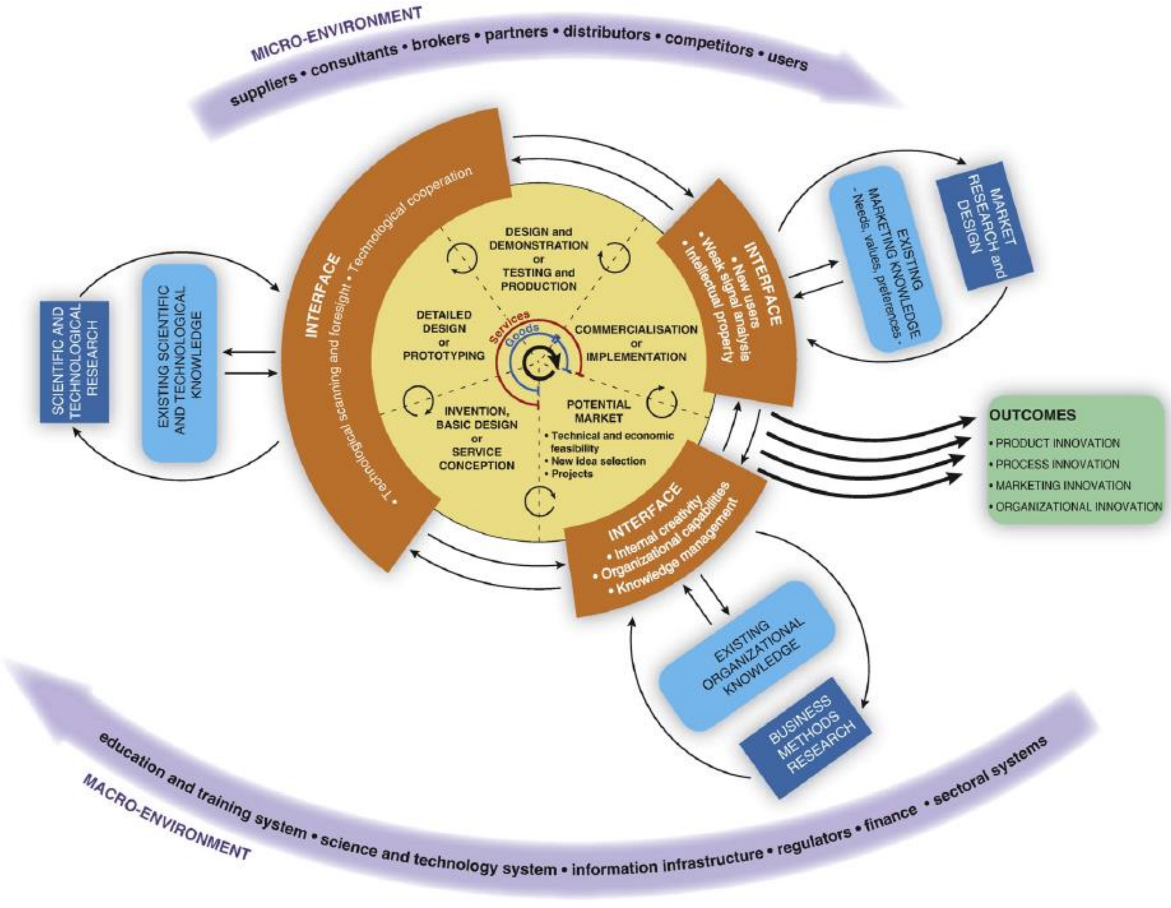
could be more effective – contribute more to enhancing competitiveness and improving quality of life – when their goals are set and tools selected following the broad approach of innovation.[7]

2.1 Linear, networked and interactive learning models of innovation

The first models of innovation had been devised by natural scientists and practitioners before economists showed a serious interest in these issues.[8] The idea that basic research is the main source of innovation had already been proposed in the beginning of the 20th century, gradually leading to what is known today as the science-push model of innovation, forcefully advocated by Bush (1945).

By the second half of the 1960s the so-called market-pull model contested that reasoning, portraying demand as the main driving force of innovation. Then a long-lasting and detailed discussion have started to establish which of these two types of models are correct, that is, whether R&D results or market demands are the most important information sources of innovations.[9]

Figure 1: The multi-channel interactive learning model of innovation



Source: Figure 3 in Caraça et al. (2009)

[7] Further details on measurement issues are presented in Section 4, while STI policy rationales derived from various economics paradigms are discussed in Section 6.

[8] This brief account can only list the most influential models; Balconi et al. (2010); Caraça et al. (2009); Dodgson and Rothwell (1994); and Godin (2006) offer detailed discussions on their emergence, properties and use for analytical and policy-making purposes.

[9] It is telling that a recent review of this discussion by Di Stefano et al. (2012) draws on one hundred papers.

Both the science-push and the market-pull models portray innovation processes as linear ones. This common feature has somewhat eclipsed the differences among these models when Kline and Rosenberg (1986) suggested the chain-linked model of innovation, stressing the non-linear property of innovation processes, the variety of sources of information, as well as the importance of various feedback loops. This latter one has then been extended into the networked model of innovation, a recent, highly sophisticated version of which is called the multi-channel interactive learning model. (Caraça et al., 2009).

Various types of links with foreign partners – privatisation and setting up new firms by foreign investors, supplier relationships with foreign-owned firms in a host country, learning via exporting to foreign markets, as well as importing advanced technologies, materials, equipment and software – are crucial sources for learning and innovation for most domestic firms in the EU10 countries.[10] Existing technological, organisational (business methods) and marketing knowledge – highlighted in the multi-channel interactive learning model – are absorbed to a large extent via these channels, and when adapted to the local context, and improved upon by own engineering and other development activities, these lead to improved productivity and enhanced competitiveness. In other words, incremental product, process, organisational, managerial and marketing innovations, as well as improvements in production capabilities are at least as important sources for better economic performance than radical product innovations drawing on sophisticated R&D activities.

2.2 Innovation in various schools of thought in economics

Technological, organisational and institutional changes – using modern terminology: different types of innovation – had been in the centre of analysis in several major works in classical economics. Then neo-classical economics essentially abandoned research questions concerned with dynamics, and instead focused on optimisation, assuming homogenous products, diminishing returns to scale, technologies accessible to all producers at zero cost, perfectly informed economic agents, perfect competition, and thus zero profit. Technological changes were treated as exogenous to the economic system, while other types of innovations were not considered at all. Given abundant empirical findings and theoretical work on firm behaviour and the operation of markets, mainstream industrial economics and organisational theory has relaxed the most unrealistic assumptions of neo-classical economics, especially perfect information, deterministic environments, perfect competition, and constant or diminishing returns. Yet, several major shortcomings have remained: (i) institutional issues are not addressed satisfactorily in these branches of economics, either; (ii) a very narrow concept of uncertainty is used; (iii) no adequate theory is offered on the creation of knowledge used in innovation activities and technological interdependence amongst firms; and (iv) the role of government is not analysed in a way that would provide a sound and constructive guidance to policy-makers. (Fagerberg et al. (eds), 2005; Foray (ed.), 2009; Lazonick, 2013; Lundvall and Borrás, 1999; Smith, 2000)

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[10] The body of literature is so huge on these issues that only a few references could be mentioned here, in a somewhat arbitrary way: Dyker (1997), (1999), (2004); Dyker (ed.) (1997); Ernst and Kim (2002); Estrin et al. (1997); Estrin and Uvalic (2014); Giroud et al. (2012); Havas (2000a), (2000b), (2007); Hirschhausen and Bitzer (eds) (2000); Inzelt (1994); Iwasaki et al. (2011), (2012); Jindra et al. (2009); Kokko and Kravtsova (2008); Lorentzen and Roostgaard (eds) (1997); Lorentzen et al. (eds) (1999); Lorentzen et al. (2003); Narula and Zanfei (2005); Pavlínek et al. (2009); Pavlínek and Zenka (2011); Piech and Radošević (eds) (2006); Radošević and Sadowski (eds) (2004); Radošević and Yoruk (2015); Saliola and Zanfei (2009); Sass and Szalavetz (2014); Stephan (ed.) (2005); Stephan (2013); Szalavetz (2012); and Szanyi (2012). See also the papers produced by WP2 and WP3 of the GRINCOH project, especially Soós et al. (2014) and the presentations given at a workshop on „Cohesion in the new EU member states: catching-up, structural change and the role of trade and FDI" (Vienna, 30 October 2014, http://www.grincoh.eu/working-papers).

Evolutionary economics of innovation rests on radically different postulates compared to mainstream economics.[11] The latter assumes rational agents, who can optimise via calculating *risks* and taking appropriate actions, while the former stresses that innovation entails *uncertainty*. Thus, *optimisation* is impossible on theoretical grounds.

Availability of *information* (symmetry vs. asymmetry among agents in this respect) has been the central issue in mainstream economics until recently. Evolutionary economics, in contrast, has stressed since its beginnings that the success of firms depends on their accumulated *knowledge* – both codified and tacit –, *skills*, as well as *learning capabilities*. Information can be purchased (e.g. as a manual, blueprint, or licence), and hence can be accommodated in mainstream economics as a special good relatively easily and comfortably. Yet, knowledge – and *a fortiori,* the types of knowledge required for innovation, e.g. tacit knowledge, skills, and proficiency in pulling together and exploiting available pieces of information – cannot be bought and used instantaneously. A learning process cannot be spared if one is to acquire knowledge and skills, and it is not only time-consuming, but the costs of *trial and error* need to be incurred as well. Thus, the uncertain, cumulative and path-dependent nature of innovation is reinforced.

Cumulativeness, path-dependence and learning lead to *heterogeneity* among firms, as well as other organisations. On top of that, sectors also differ in terms of major properties and patterns of their innovation processes. (Castellacci, 2008; Malerba, 2002; Pavitt, 1984; Peneder, 2010)

Innovators are not lonely champions of new ideas. While talented individuals may develop radically new scientific or technological concepts, successful innovations require various types and forms and knowledge, rarely possessed by a single organisation. A close collaboration among firms, universities, public and private research organisations, and specialised service-providers is, therefore, a prerequisite of major innovations. (Freeman 1991, 1994, 1995; Lundvall and Borrás, 1999; OECD, 2001; Smith, 2000, 2002; Tidd et al., 1997) In other words, 'open innovation' is not a new phenomenon at all. (Mowery, 2009)

Given this analytical framework – as already stated in the Introduction – first the structural composition of the EU10 countries' NIS is described, including their dynamics, followed by the characterisation of their innovation performance, and a detailed account of the collaboration among the various NIS actors.

3 Structural changes in the national innovation systems of the EU10 countries

3.1 Main actors in STI policy-making

Responsibilities for STI policy-making in the EU10 countries – just as practically in all EU member states, as well as beyond the EU – are typically divided between ministries responsible for the economy and those overseeing higher education.[12] Competition between these ministries and their subordinate agencies might

[11] The so-called new or endogenous growth theory is not discussed here separately because its major implicit assumptions on knowledge are very similar to those of mainstream economics. (Lazonick, 2013; Smith, 2000) Moreover, knowledge in new growth models is reduced to codified scientific knowledge, in sharp contrast to the much richer understanding of knowledge in evolutionary economics of innovation. When summarising the "evolution of science policy and innovation studies" (SPIS), Martin (2012: 1230) also considers this school as part of mainstream economics: "Endogenous growth theory is perhaps better seen not so much as a contribution to SPIS but rather as a response by mainstream economists to the challenge posed by evolutionary economics."

[12] There is a huge variety among the EU10 countries – just as in all other countries – as to how these ministries are called, and how wide their portfolio is, e.g. including transport, infrastructure and/ or further policy domains in the first group of ministries, and youth, sports, health, etc. in the latter group. The actual composition of these portfolios might make an important difference, indeed, but for our current analysis what really matters is this 'duality' of responsibilities of various STI policy tools. Of course, several other ministries or government agencies, responsible e.g. for planning the central budget, competition policy or

have some stimulating effects – who can come up with more useful ideas, who can devise and implement more effective policy tools – but it is more likely to lead to conflicting policy actions, diminishing each other's effects, or double funding of the same activity. To avoid these mishaps, high-level policy co-ordination bodies have been set up in 8 of the EU10 countries (the exceptions are Bulgaria and Poland).[13] These bodies, however, in most cases only have an advisory or consultative role, i.e. not decision-making competences. Thus there is a considerable room for improvement in co-ordinating STI policies so as to make these policy tools more effective, and thus use of public money more efficient.

Moreover, the STI policy governance sub-system is frequently reorganised in the EU10 countries, at least once when a new government takes office.[14] These frequent changes in governance structures prevent organisational learning by policy design and implementation bodies, and this lack of stability also hinders their efficient functioning. Further, constant re-organisations put a significant administrative burden on research and innovation performers, and thus hamper innovation performance.

3.2 Main research performers

The business sector is the most important research performer at an aggregate level in the EU27 both in terms of its share in GERD and employment, followed by the higher education and the government sectors, respectively. (Table 1) The share of the private non-profit sector is around 1% by either measure, and thus it is not analysed here.

Table 1: R&D inputs and the weight of R&D performing sectors, EU27, 2000 and 2012 (%)

	2000	2012
GERD/GDP	1.85	2.08
Share of researchers (FTE) in total employment	0.54	0.77
Business sector		
BERD/GERD	63.75	62.36
Share of business researchers (FTE)	46.00	46.48
Higher education sector		
HERD/GERD	21.18	23.88
Share of HE researchers (FTE)	37.69	40.16
Government sector		
GOVERD/GERD	14.29	12.89
Share of government researchers (FTE)	15.24	12.17

Source: Eurostat and own calculation based on Eurostat data

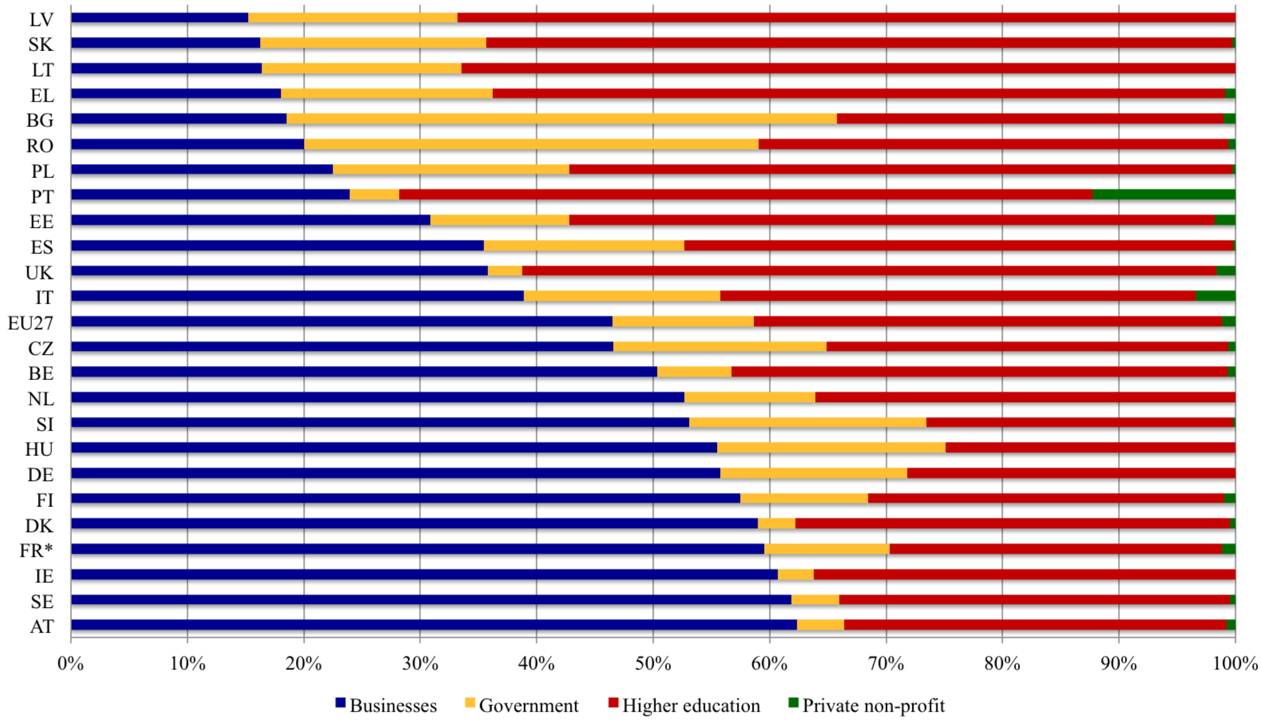
This pattern is not repeated at a country level: in 2012 businesses were the largest employers of (FTE) researchers in 12 EU countries, while the higher education sector took the lead in 11 EU countries, and the government sector in a single member state. The share of business enterprise researchers in the EU27 total

regional development also exert a major influence on innovation processes via their own toolboxes (subsidies, regulations, etc.). The ERAWATCH Annual Country Reports provide details on the STI policy governance sub-systems in all EU member states.

[13] The actual operation of these co-ordination bodies is an important issue. For example, from time to time the respective bodies only exist on paper in Hungary and Romania, but actually do not work, or not even set up in practice. (Gheorghiu, 2014; Havas, 2011, 2015c)

[14] Hungary is an extreme case: the highest level STI policy co-ordination body has been dissolved and then re-established four times in 2009-2014, while the main technology and innovation policy implementing agency 5 times in 1999-2015. (Havas, 2015c)

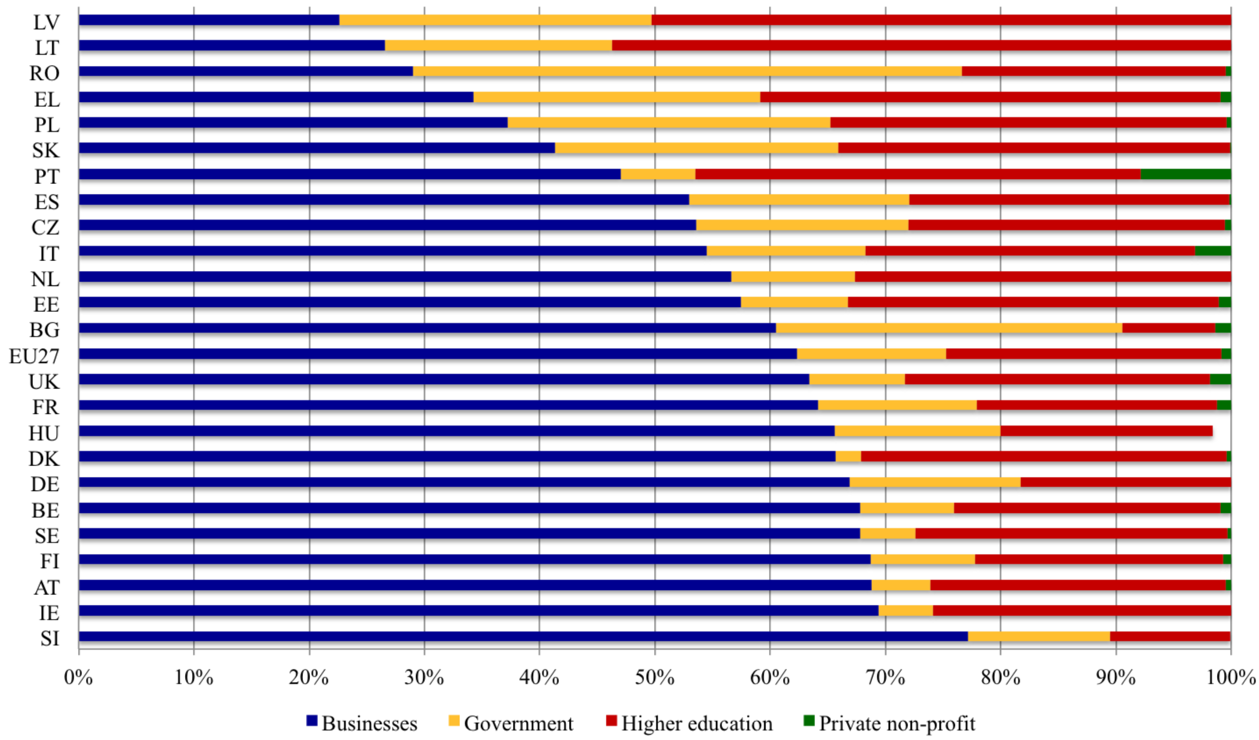
Figure 2: Share of research performing sectors in employing FTE researchers, EU countries, 2012



Source: compiled by using Eurostat data

** 2011 data*

Figure 3: Share of research performing sectors in performing GERD, EU countries, 2012



Source: compiled by using Eurostat data was 46.5% in 2012 and varied between 15.2% (LV) and 62.3% (AT) in the national total at a country level. (Figure 2) The share of GERD performed by the business enterprise sector was 62.4% in 2012. At a country level this ratio was ranging between 22.6% (LV) and 77.2% (SI) in 2012. (Figure 3)

Higher education (HE) organisations were the second largest employers with 412,473 FTE researchers in 2000 at the EU27 level and 660,040 in 2012, that is, 40.2% of the EU27 total. Again, there is a great variety at a national level: the share of HE FTE researchers in the national total was ranging between 24.9% (HU) and 66.8% (LV) in 2012. (Figure 2) The share of GERD performed by the HE sector is significantly lower: it fluctuated between 21.2% and 23.9% in 2000-2012 at the aggregate level of 27 EU countries. (Figure 3)

At an aggregate EU27 level *the government sector* was the No. 3 employer with 166,791 FTE researchers in 2000, and 200,045 in 2012. The share of this sector was 12.2% of the EU27 total in 2012, but the variation at the country level is significant in this case, too: the weight of the government sector is ranging between 3.0% (UK) and 47.3% (BG). (Figure 2) The share of GERD performed by the government sector was in line with its share in employment, that is, 12.9% in 2012 at the aggregate EU27 level. At the country level this share varied from 2.2% (DK) to 47.6% (RO) in 2012. (Figure 3)

The combined weight of EU10 countries in the EU27, measured by the number of FTE researchers, was below 15% in 1996, and has decreased by 3 percentage points by 2012.[15] (Table 2) In absolute terms the number of FTE researchers have increased since 1996 at the EU10 level (although some drop has occurred in Bulgaria, Romania and Slovakia in certain periods, see Table A3), and thus the decreasing share of the EU10 countries is due to a faster increase of the number of researchers in the other EU countries. The biggest decline has occurred in the government sector (publicly financed R&D institutes), where the difference in dynamics has been the largest.

Table 2: The share of EU10 countries' FTE researchers in EU27 total by research performing sectors

	1996	2000	2006	2012
All sectors	14.70%	12.97%	11.70%	11.71%
Business enterprise sector	9.84%	7.64%	6.47%	7.82%
Government sector	27.35%	23.76%	23.62%	21.73%
Higher education sector	16.02%	15.40%	14.16%	13.41%
Private non-profit sector	n.a.	2.74%	3.09%	3.75%

Source: own calculation based on Eurostat data

When measured by R&D expenditures (million €, current prices), the combined weight of EU10 countries in the EU27 is much smaller. It was below 2% in 1996, and from this hardly noticeable level has more than doubled by 2012.[16] (Table 3) In absolute terms R&D expenditures have increased since 1996 both at the EU10 and EU27 levels (Table A4), and thus the increasing share of the EU10 countries is due to a faster increase of their R&D expenditures – from an extremely low level. Interestingly, while the biggest decline in the share of FTE researchers has occurred in the government sector (publicly financed R&D institutes), this sector has more than doubled its share when it is measured in R&D expenditures. The largest increase has occurred in the higher education sector: its weight has grown by more than three times.

[15] To compare, the combined weight of the EU10 countries' GDP in the total EU28 GDP was 9.3-10.9% in 1996-2006, and then 12.2-12.8% in 2008-2013. (Table A1) The share of the EU10 was significantly higher in the EU28 population than that in the EU27 FTE researchers. (Table A2)

[16] To compare, the share of the EU10's GERD was significantly lower in the EU27 total than that in the total EU28 GDP: 4.01% vs. 12.6% in 2012. (Table 3 and Table A1)

Table 3: The share of EU10 countries' R&D expenditures in the EU27 total by research performing sectors

	1996	2000	2006	2012
All sectors	1.67%	1.84%	2.62%	4.01%
Business enterprise sector	1.33%	1.33%	1.92%	3.11%
Government sector	3.28%	3.92%	5.65%	7.30%
Higher education sector	1.53%	2.07%	2.85%	4.77%
Private non-profit sector	0.46%	0.71%	1.10%	1.68%

Source: own calculation based on Eurostat data

Notes: The 1996 shares are calculated without Estonia as those data are not available, but that is a negligible omission. The 2012 shares are calculated by using EU28 data, but again, that causes hardly any difference given the low amount of Croatian R&D expenditures, of which GOVERD is not available for 2012, and thus EU27 data cannot be calculated.

3.3 Diversity and change in the EU10 countries' research sub-systems

As already shown, the structural composition of the EU10 countries' research sub-systems was rather diverse in 2012. (Figures 2-3) For instance, the business sector in Hungary, Slovenia and the Czech Republic employed a higher share of FTE researchers than the EU27 total, while this ratio was less than half of the EU27 ratio in six EU10 countries (PL, RO, BG, LT, SK, and LV in a decreasing order). In four of these latter countries the higher education (HE) sector was a dominant employer, while in Bulgaria the government sector, and in Romania these two sectors had an equal weight. Similarly, the business sector performed a higher share of GERD in Slovenia and Hungary than the EU27 total. In contrast, this ratio was significantly below the EU27 total in SK, PL, RO, LT, and LV.

This diversity observed in 2012 is somewhat surprising for those who would assume a more similar structural composition, given the broadly similar legacies of these countries. In brief, they had been characterised by a highly centralised, politically controlled academic sector,[17] with a limited (or hardly any) autonomy in certain fields of investigations, especially in social sciences and humanities, and a rigid division of labour between universities, focussing mainly on teaching, on the one hand, and institutes of the Academies of Sciences,[18] almost exclusively performing research, on the other.[19] Hence, it worth looking at the dynamics of these sectors by taking two snapshots, that is, comparing the structural composition of the research sub-systems of these countries in 2000 and 2012.

Major structural changes have occurred since 2000 in several countries. For instance, the weight of *business sector* in employing FTE researchers has increased by over 20 percentage points in three countries (Hungary, Slovenia, and Estonia), by over 10 in Lithuania, and by 5-7 in the Czech Republic, Bulgaria, and Poland. In contrast, this weight has decreased by 8-11 percentage points in Slovakia and Latvia, and by over 40 in Romania. (Figure 4, Table 4) The *government sector* has lost 3 percentage points at the EU27 level, and changes in the same direction have occurred in 8 of the EU10 countries, too: by over 9-20 percentage points in six countries, and by 3-6 in two. This ratio has remained practically the same in Latvia, while increased considerably in Romania (by 13.4 percentage points). The *higher education sector* gained 2.5

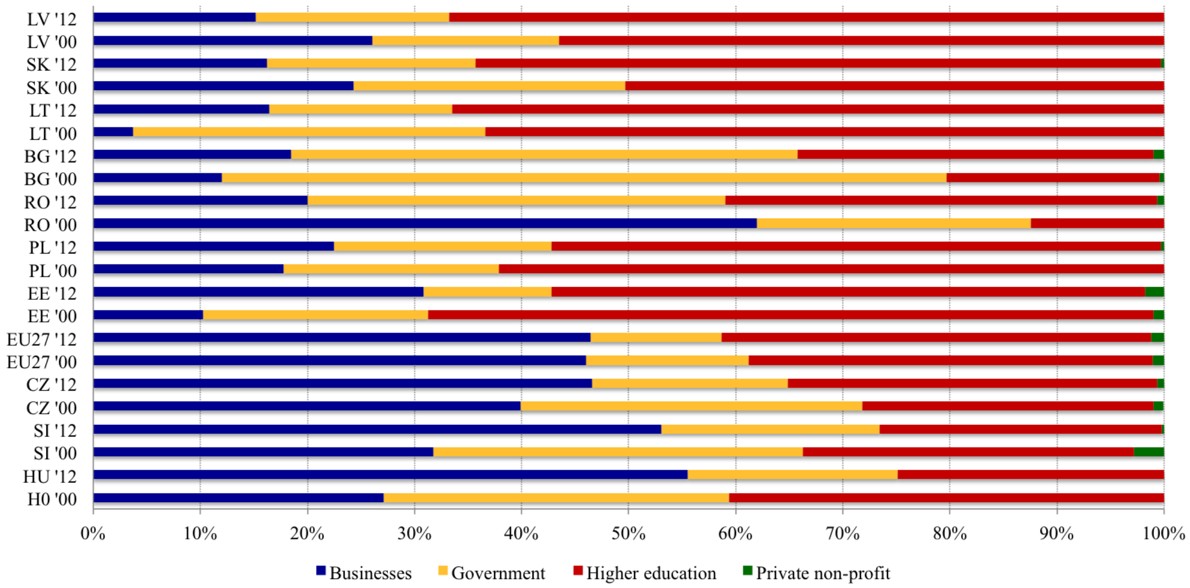
[17] Given the prominent role of the Academies of Sciences in most of these countries, probably it is useful to stress even nowadays that this term denotes all publicly financed research organisations, that is, mainly universities and other public research institutes.

[18] These institutes belong to the government sector in the EU and OECD classification of research performing sectors.

[19] On the historical legacies and early transition of the research sub-systems in the EU10 countries, see, e.g. Acha and Balazs (1999); Adamsone-Fiskovica et al. (2011); Balazs et al. (eds) (1995); Chataway (1999); Kristapsons et al. (2003); Meske (2000); Meske et al. (eds) (1998); Meske (ed.) (2004); Radošević (1997), (1998), (1999); Radošević and Auriol (1999); Webster (ed.) (1996).

percentage points at the EU27 level, 3-7 in two of the EU10 countries, 10-14 in another three, 28 percentage points in Romania, while lost around 5 in two, and 12-16 in the remaining two ones.

Figure 4: Share of research performing sectors in employing FTE researchers, EU10 countries, 2000 and 2012



Source: compiled by using Eurostat data

Note: Countries are ranked by the weight of their business sector in 2012.

Table 4: Changes in the weight of the research performing sectors in employing FTE researchers, EU10 countries, 2012 compared to 2000 (percentage point)

	Business sector	Government sector	Higher education sector
Hungary	28.4	-12.7	-15.7
Slovenia	21.3	-14.2	-4.5
Estonia	20.6	-9.0	-12.3
Lithuania	12.7	-15.8	3.1
Czech Republic	6.7	-13.6	7.3
Bulgaria	6.5	-20.4	13.3
Poland	4.7	0.2	-5.2
EU27	0.5	-3.1	2.5
Slovakia	-8.0	-6.0	13.8
Latvia	-10.9	0.6	10.3
Romania	-42.0	13.4	28.0

Source: own calculation based on Eurostat data

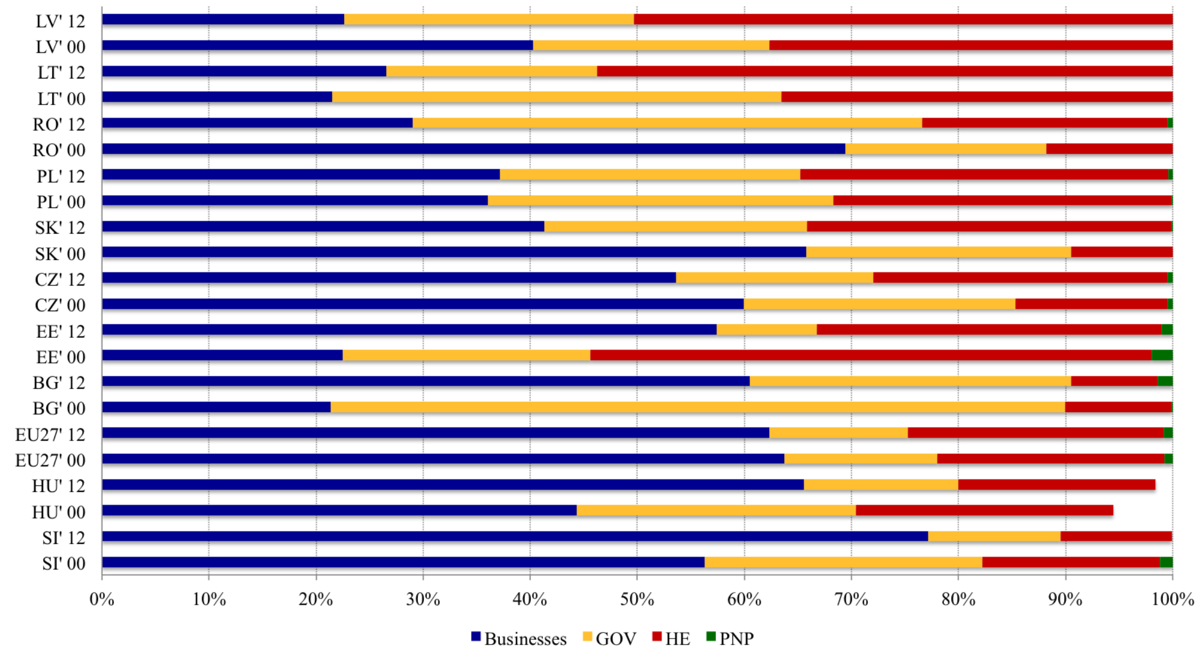
Note: Countries are ranked by the change in the weight of their business sector.

The sectoral composition of a research sub-system can be measured by the share of BERD, GOVERD, and HERD, too. This metrics also indicate major structural changes since 2000 in all EU10 countries, except Poland. The weight of *business sector* in performing GERD has increased by over 20 percentage points in four countries (Bulgaria, Estonia, Hungary, and Slovenia), and decreased by 18-40 in Romania, Slovakia, and Latvia.[20] (Figure 5, Table 5) The *government sector* has lost a mere 1.4 percentage points at the EU27 level, but 12-39 points in five of the EU10 countries, 4-7 percentage points in another two countries. This ratio has remained practically the same in Slovakia, while increased considerably in Romania (by nearly 29

[20] More details concerning some of these cases are presented in Havas (2015a).

points) and by 5 percentage points in Latvia. The *higher education sector* gained 2.7 percentage points at the EU27 level, around 3 in Poland, 11-25 points in five of the EU10 countries, while lost 2-6 percentage points in three, and over 20 points in Estonia.

Figure 5: Share of research performing sectors in performing GERD, EU10 countries, 2000 and 2012



Source: compiled by using Eurostat data

Note: Countries are ranked by the weight of their business sector in 2012.

Table 5: Changes in the weight of the research performing sectors in performing GERD, EU10 countries, 2012 compared to 2000 (percentage point)

	Business sector	Government sector	Higher education sector
Bulgaria	39.1	-38.6	-1.8
Estonia	34.9	-13.8	-20.2
Hungary	21.3	-11.7	-5.6
Slovenia	20.9	-13.6	-6.2
Lithuania	5.1	-22.3	17.2
Poland	1.1	-4.2	2.9
EU27	-1.4	-1.4	2.7
Czech Republic	-6.4	-6.9	13.3
Latvia	-17.7	5.0	12.7
Slovakia	-24.5	-0.2	24.5
Romania	-40.4	28.7	11.2

Source: own calculation based on Eurostat data

Note: Countries are ranked by the change in the weight of their business sector.

In sum, while the structural composition of the research sub-system of the EU10 countries showed a great diversity already in 2000 – for instance the weight of the business sector in employing FTE researchers was ranging from 4% (Lithuania) to 62% (Romania) and in performing GERD from 21% (Bulgaria) to 56% (Slovenia) –, fairly significant changes have occurred since then almost in all countries, adding more colours to the observed diversity. *Changes have occurred in both directions in all the three major research performing sectors*, taking either the share of FTE researchers or the share of GERD performed. Thus *neither a similar structural composition of the research sub-system can be observed, nor a move towards a similar structure*.

4 Innovation performance of the EU 10 countries

Scientific performance of the EU10 countries is discussed in detail in other GRINCOH papers, especially by Płoszaj and Olechnicka (2015) and Radošević and Yoruk (2013), as well as in a large number of further publications, see, e.g. Kozak et al. (2015), Kozlowski et al. (1999), Must (2006), Pajić (2015), Radošević and Yoruk (2014). Hence the focus here is on innovation performance.

Although various indicators measuring patenting activity are widely used, either as a proxy of, or even a direct measure of, innovation performance, these are not reported here as patenting is more of a signal of strategic intentions – to commercialise an idea at a later stage or prevent competitors from using certain pieces of information – than a measure of innovation activities. In any case, interested readers can easily find comparable data on patenting activities e.g. among the Innovation Union Scoreboard indicators. More importantly, technology upgrading of the EU10 countries, exploring patent data, is thoroughly discussed in another GRINCOH paper by Jindra et al. (2015), while patenting activities of CEE countries (as a region) by Dominguez Lacasa and Giebler (2013).

Significant progress has been achieved in measuring R&D and innovation activities since the 1960s (Grupp, 1998; Grupp and Schubert, 2010; Smith, 2005) with the intention to provide comparable data sets as a solid basis for assessing R&D and innovation performance and thereby guiding policy-makers in devising appropriate policies.[21] Although there are widely used guidelines to collect data on R&D and innovation – the Frascati and Oslo Manuals (OECD, 2002 and 2005, respectively) –, it is not straightforward to find the most appropriate way to assess R&D and innovation performance. To start with, R&D is such a complex, multifaceted process that it cannot be sufficiently characterised by two or three indicators, and that applies to innovation *a fortiori*. Hence, there is always a need to select a certain set of indicators to depict innovation processes, and especially to analyse and assess innovation performance. The choice of indicators is, therefore, an important decision reflecting the mindset of those decision-makers who have chosen them. These figures are 'subjective' in that respect, but as they are expressed in numbers, most people perceive indicators as being 'objective' by definition.

There is a fairly strong – sometimes implicit, other times rather explicit – pressure to devise so-called composite indicators to compress information into a single figure in order to compile eye-catching, easy-to-digest scoreboards. Two caveats are in order here. First, a major methodological snag is choosing an appropriate weight to be assigned to each component. By conducting sensitivity analyses of the 2005 European Innovation Scoreboard (EIS), Grupp and Schubert (2010: 72) have shown how unstable the rank configuration is when the weights are changed. Besides assigning weights, three other ranking methods are also widely used, namely: unweighted averages, Benefit of the Doubt (BoD) and principal component analysis. Comparing these three methods, the authors conclude: "(…) even using accepted approaches like BoD or factor analysis may result in drastically changing rankings." (ibid: 74) That methodological difficulty actually reveals a substantive one: both for thorough, more reliable analyses, and better policy decisions the multidimensional character of innovation processes and performance needs to be reflected. Grupp and Schubert (2010: 77), therefore, propose using multidimensional representations, e.g. spider charts. That would enable analysts and policy-makers to identify strengths and weaknesses, that is, more precise targets for policy actions.

[21] "The Innovation Union Scoreboard 2014 gives a comparative assessment of the innovation performance of the EU27 Member States and the relative strengths and weaknesses of their research and innovation systems." (EC, 2014: 7) The same (or similar) sentence appears in earlier editions of the IUS, too.

Other researchers also emphasise the need for a sufficiently detailed characterisation of innovation processes. For example, a family of five indicators – R&D, design, technological, skill, and innovation intensities – offers a more diversified picture on innovativeness than the Summary Innovation Index of the EIS. (Laestadius et al., 2005) Using Norwegian data they demonstrate that the suggested method can capture variety in knowledge formation and innovativeness both within and between sectors. It thus supports a more accurate understanding of creativity and innovativeness inside and across various sectors, directs policy-makers' attention to this diversity (suppressed by the OECD classification of sectors), and thus can better serve policy needs.

Keeping in mind these caveats, the modest intention here is to describe the dynamics of EU10 innovation performance in two simple ways: (i) using three series elementary data, namely the share of innovative firms, that of turnover from innovation, as well as labour productivity; and (ii) recalling their position on various scoreboards, relying on composite indicators.

4.1 The share of innovative enterprises and turnover from innovation

The share of innovative enterprises in Estonia has been consistently above the EU27 aggregate figure since 1998-2000, the Czech figures remained slightly below that mark, and Slovenia has made a significant progress, almost closing the gap. The other 7 of the EU10 countries seem to play in a different league. (Table 6)

This ratio has fluctuated quite considerably in a number of EU10 countries since 1998, e.g. in Bulgaria in the range of 11.4-23.9%, in Lithuania between 18.9% and 28.5%, in Romania from 6.3% to 20.7%, while in Slovenia the difference between the lowest and highest values has been 14 percentage points. In general, there is neither a clear increasing nor a decreasing trend in the share of innovative firms, with three exceptions. This ratio in Hungary was falling from a fairly low level (23.3%) in 1998-2000 to 16.4% in 2010-2012 and in Lithuania from a higher level (28.0%) in 1998-2000 to 18.9% by the end of the observed period. In contrast, the Slovene data had shown a nearly monotonous growth until 2008-2010 (from 21.1% to 34-35% in three periods), then a small decrease in 2010-2012. An inverted U shape (growth followed by contraction) can be observed in Bulgaria, Estonia, Poland, Romania, and Slovakia. Following a sharp increase, a sort of oscillation can be observed in the Czech Republic, in a relatively close range, that is, 35-39%. The Latvian figures have also been swinging in a narrow space (16-20%).[22]

It would not be a well-substantiated claim to establish the impacts of the 2008 global financial and economic crisis on innovation activities in the EU10 countries just relying on this set of figures.[23] Yet, it is noteworthy that in 8 of the EU10 countries the share of innovative firms dropped by 1-6 percentage points by 2008-2010 compared to the previous period. It practically remained at the same level in Slovenia, and considerably increased in Slovakia. 2010-2012 saw a further decrease in 5 of the former 8 countries – a particularly dramatic one in Romania to a mere 6.3% –, Slovakia, too, joined the group of countries reporting a lower share of innovative firms, and Slovenia also experienced some decline. In essence no change was recorded in Poland in this period, while some of the previous loss was recovered in the Czech Republic and Latvia.

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[22] Data on the share of innovative firms by size categories are presented in Tables A5-A14.

[23] Izsak and Radošević (2015) is analysing the impacts of the crisis on innovation policies, in particular on public spending, in various EU regions, including the EU10 countries. See also Izsak et al. (2013).

Table 6: The share of innovative enterprises in the EU10 countries, 1998-2012 (%)

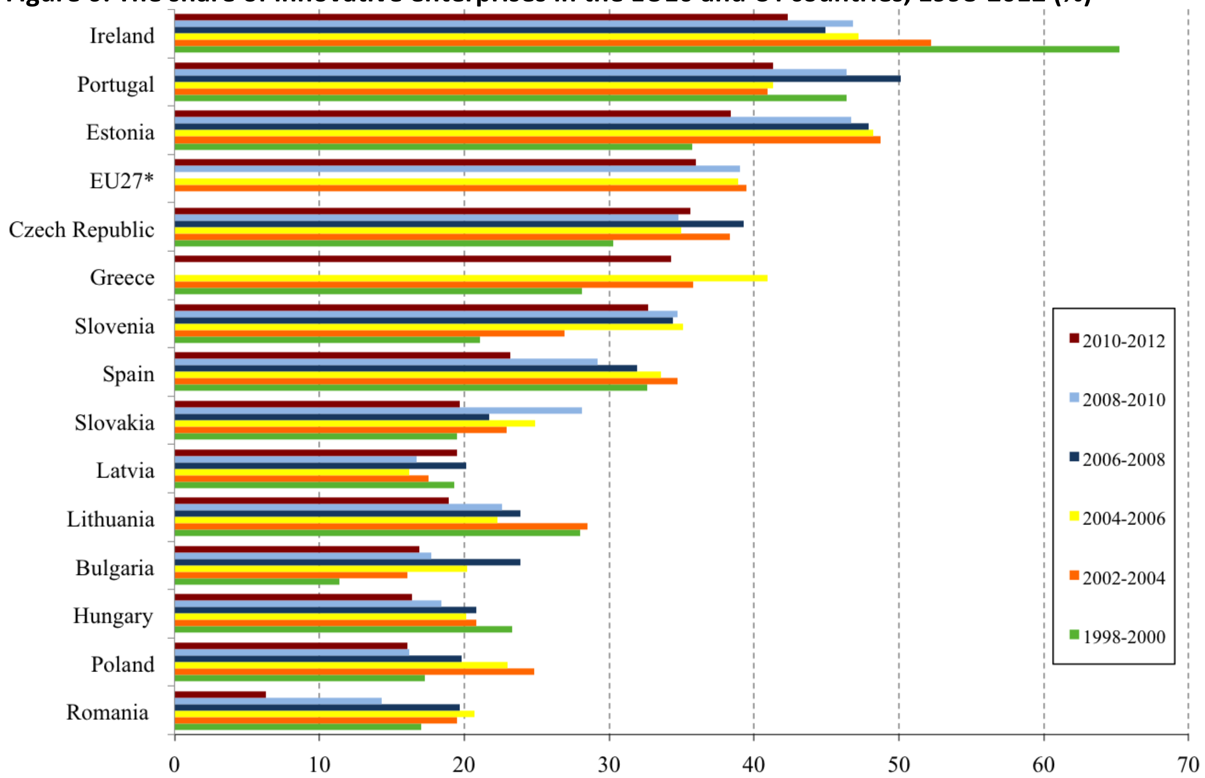
	1998-2000	2002-2004	2004-2006	2006-2008	2008-2010	2010-2012
Estonia	35.7	48.7	48.2	47.9	46.7	38.4
EU27*	n.a.	39.5	38.9	n.a.	39.0	36.0
Czech Republic	30.3	38.3	35.0	39.3	34.8	35.6
Slovenia	21.1	26.9	35.1	34.4	34.7	32.7
Slovakia	19.5	22.9	24.9	21.7	28.1	19.7
Latvia	19.3	17.5	16.2	20.1	16.7	19.5
Lithuania	28.0	28.5	22.3	23.9	22.6	18.9
Bulgaria	11.4	16.1	20.2	23.9	17.7	16.9
Hungary	23.3	20.8	20.1	20.8	18.4	16.4
Poland	17.3	24.8	23.0	19.8	16.2	16.1
Romania	17.0	19.5	20.7	19.7	14.3	6.3

Source: Eurostat, various rounds of CIS

** EU28 in 2010-2012*

The share of innovative firms in the 'classic' cohesion countries, that is, Greece, Ireland, Portugal and Spain (C4), tend to be higher than in the EU10 countries. Greece had achieved a remarkable progress, surpassing the EU27 aggregate figure in 2004-2006, then suffered a decline by 2010-2012. Ireland had started from an extremely high level in 1998-2000 and despite losing 23 percentage points by 2010-2012 remained well above the EU27 figure. The Portuguese ratio has been fluctuating between 41-50%, that is, a fairly high level. The Spanish data had stayed in the range of 32-35% until 2006-2008 and then fell dramatically: to 23.2% in 2010-2012. (Figure 6)

Figure 6: The share of innovative enterprises in the EU10 and C4 countries, 1998-2012 (%)

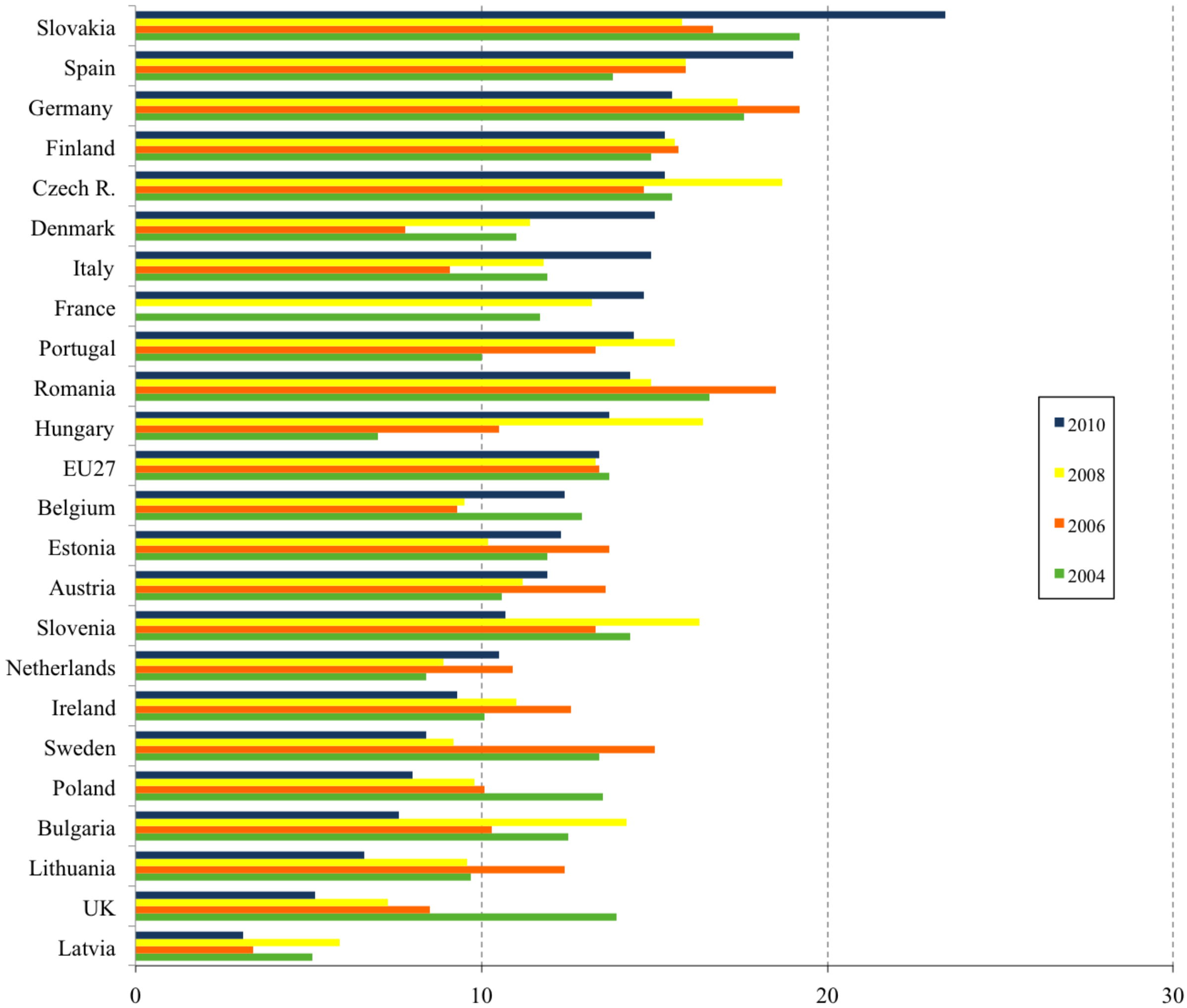


Source: Eurostat, various rounds of CIS

** EU28 in 2010-2012*

Detailed data on the share of turnover from innovation – making a distinction between goods new to the firm vs. new to the market – are available for neither 2008-2010, nor 2010-2012. Thus, only more aggregated data can be used here. There are fairly big differences among the EU10 countries by this ratio: 3-6% in Latvia, while 16-23% in Slovakia. Thus, the EU10 countries are not grouped together on Figure 7. From a different angle, countries at a rather different level of techno-economic performance are next to each other along this measure, e.g. Latvia, the UK, Lithuania, Bulgaria, Poland, and Sweden at the lower end of Figure 7, while Slovakia, Germany, and Finland at the upper end. Hence, probably one should not overestimate the significance of these data. Instead of using them to jump to pretentious conclusions (e.g. by journalists, spin doctors or politicians), they should be taken as eye-opening questions to improve the Community Innovation Survey.

Figure 7: Turnover from innovation, selected EU countries, 2004-2010 (% of total turnover)



Source: Eurostat, various rounds of CIS

4.2 Change in labour productivity

Innovation, especially process, managerial and organisational innovations, can enhance productivity, and thus data on labour productivity can also be used to characterise innovation performance. Using this lens, the top four EU10 performers are Latvia, Lithuania, Romania, and Estonia with an improvement by 17-23 percentage points between 2002-2012. Another four of the EU10 countries have achieved a change between 5-10 percentage points, while Hungary and the Czech Republic have recorded the smallest improvements, that is, 7.6, and 5.0 percentage points, respectively. It should be noted, though, that these latter countries were ranked 2 and 4, respectively, among the EU10 countries in 2002, while three of the four best performers were at the bottom of the list in that year: Latvia (9), Romania (10), and Estonia (7). Three of the four 'classic' cohesion countries started from a higher level of labour productivity compared to the EU10 countries in 2002. Ireland and Spain saved their No. 1 and No. 2 standing, respectively, in 2012, while both Greece and Portugal lost 2 positions. (Table 7)

Table 7: Labour productivity per hour worked in the EU10 and C4 countries, 2002-2012 (EU27 = 100)

	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	change
Latvia	33.4	34.5	36.5	37.4	38.4	47.9	45.8	48.2	51.7	53.9	56.2	22.8
Lithuania	45.3	49.2	49.9	49.2	51.0	52.9	54.1	51.1	59.6	64.1	65.4	20.1
Romania	26.5	28.5	31.5	32.7	35.5	38.5	43.5	43.4	44.0	43.9	44.4	17.9
Estonia	43.4	46.3	48.5	50.7	52.0	55.6	55.6	59.2	60.6	60.0	60.7	17.3
Slovakia	60.3	62.8	63.4	65.1	67.4	71.1	74.0	73.8	75.1	75.0	75.2	14.9
Poland	47.7	48.5	49.8	49.7	49.0	49.9	50.1	52.4	56.3	58.1	59.3	11.6
Slovenia	75.8	76.6	78.8	82.1	83.4	83.7	83.4	83.9	82.9	85.9	86.3	10.5
Ireland	118.9	122.0	122.3	120.5	120.3	121.9	114.6	120.5	126.0	129.2	128.8	9.9
Bulgaria	34.6	35.4	35.1	36.2	36.7	37.8	39.0	39.6	41.0	43.1	44.4	9.8
Hungary	54.3	55.8	56.6	57.0	57.0	56.1	59.3	60.5	60.3	60.6	61.9	7.6
Spain	102.0	101.4	100.7	100.7	102.5	103.6	104.3	107.6	105.0	104.2	107.9	5.9
Czech R.	62.3	65.6	67.0	67.0	68.2	70.9	68.4	70.1	67.6	67.9	67.3	5.0
Portugal	61.4	61.6	60.5	63.0	63.2	63.5	63.4	64.9	65.7	64.6	65.2	3.8
Greece	79.8	81.1	81.5	76.7	78.4	78.1	83.3	80.8	76.0	72.7	73.9	-5.9

Source: Eurostat, and own calculations

Note: Countries are ranked by change in their labour productivity.

Comparing the data in Table 6 and Table 7 reveals a puzzle, indicating a need for detailed country analyses. For example, Estonia consistently has had the highest share of innovative enterprises among the EU10 countries since 1998-2000 – and that share has been above the EU27 aggregate figure, too –, while Romania, with a significantly lower share of innovative enterprises – ranked 8-9 in every rounds of the CIS among the EU10 countries – achieved a slightly higher improvement in labour productivity (17.9 vs. 17.3 points) albeit starting from a considerably lower level (26.5% vs. 43.4% of the EU27 level). Latvia and Lithuania are somewhat similar cases: in spite of the low share of innovative enterprises (both in absolute terms and relative to the other EU10 countries) they are No. 1 and No. 2 in terms of enhancing labour productivity, and in case of Lithuania not even from a particularly low level (45.3% of the EU27 level, No. 6 among the EU10 countries). At the other extreme, the Czech Republic has shown the smallest improvement in labour productivity (a mere 5 points by 2012) with a share of innovative enterprises close to the EU27 figure, albeit from a relatively high level (62.3% of the EU27 level in 2002).[24]

4.3 Innovation Union Scoreboard, Summary Innovation Index

The EC is using the Innovation Union Scoreboard (IUS) as its principal measurement and monitoring tool to assess the innovation performance of the EU member states. Until 2012 it was called the European Innovation Scoreboard and its indicators have been revised several times since its first edition in 2002. A composite indicator, called the Summary Innovation Index (SII), is also calculated annually to summarise innovation performance and rank member states by this tool. Given this prominent role of the SII, it is worth looking at it in some details. Its 2014 edition is based on 25 indicators, grouped by 8 innovation

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[24] In a detailed analysis several factors need to be considered, including structural changes, business cycles, changes in product portfolio, prices and profits. For example, while at a micro level innovation indeed is the main source of productivity improvement (strictly defined), at a macro level a higher level of productivity can be achieved by re-allocating resources from less efficient firms (sectors) to more efficient ones.

dimensions. (EC, 2014) A rudimentary classification exercise reveals a strong bias towards R&D-based innovations: 10 indicators are *only* relevant for, and a further four *mainly* capture, R&D-based innovations; seven could be relevant for both types of innovations; and a mere four are focusing on non-R&D-based innovations. (Table 8) Given that (i) the IUS is used by the European Commission to monitor progress, and (ii) its likely impact on national policy-makers, this bias towards R&D-based innovation is a source of major concern.

Table 8: The 2014 Innovation Union Scoreboard indicators

	Relevance for R&D- based innovation	Relevance for non-R&D- based innovation
Human resources		
New doctorate graduates (ISCED 6) per 1000 population aged 25-34	X	
Percentage population aged 30-34 having completed tertiary education	b	b
Percentage youth aged 20-24 having attained at least upper secondary level education	b	b
Open, excellent and attractive research systems		
International scientific co-publications per million population	X	
Scientific publications among the top 10% most cited publications worldwide as % of total scientific publications of the country	X	
Non-EU doctorate students1 as a % of all doctorate students	X	
Finance and support		
R&D expenditure in the public sector as % of GDP	X	
Venture capital investment as % of GDP	x	
Firm investments		
R&D expenditure in the business sector as % of GDP	X	
Non-R&D innovation expenditures as % of turnover		X
Linkages & entrepreneurship		
SMEs innovating in-house as % of SMEs	b	b
Innovative SMEs collaborating with others as % of SMEs	b	b
Public-private co-publications per million population	X	
Intellectual assets		
PCT patents applications per billion GDP (in PPS€)	X	
PCT patent applications in societal challenges per billion GDP (in PPS€) (environment-related technologies; health)	X	
Community trademarks per billion GDP (in PPS€)		X
Community designs per billion GDP (in PPS€)		X
Innovators		
SMEs introducing product or process innovations as % of SMEs	b	b
SMEs introducing marketing or organisational innovations as % of SMEs		X
Economic effects		
Employment in fast-growing enterprises in innovative sectors (% of total employment)	b	b
Employment in knowledge-intensive activities (manufacturing and services) as % of total employment	x	
Contribution of medium and high-tech product exports to the trade balance	x	
Knowledge-intensive services exports as % total service exports	x	
Sales of new to market and new to firm innovations as % of turnover	b	b
License and patent revenues from abroad as % of GDP	X	

Legend:

X: only relevant

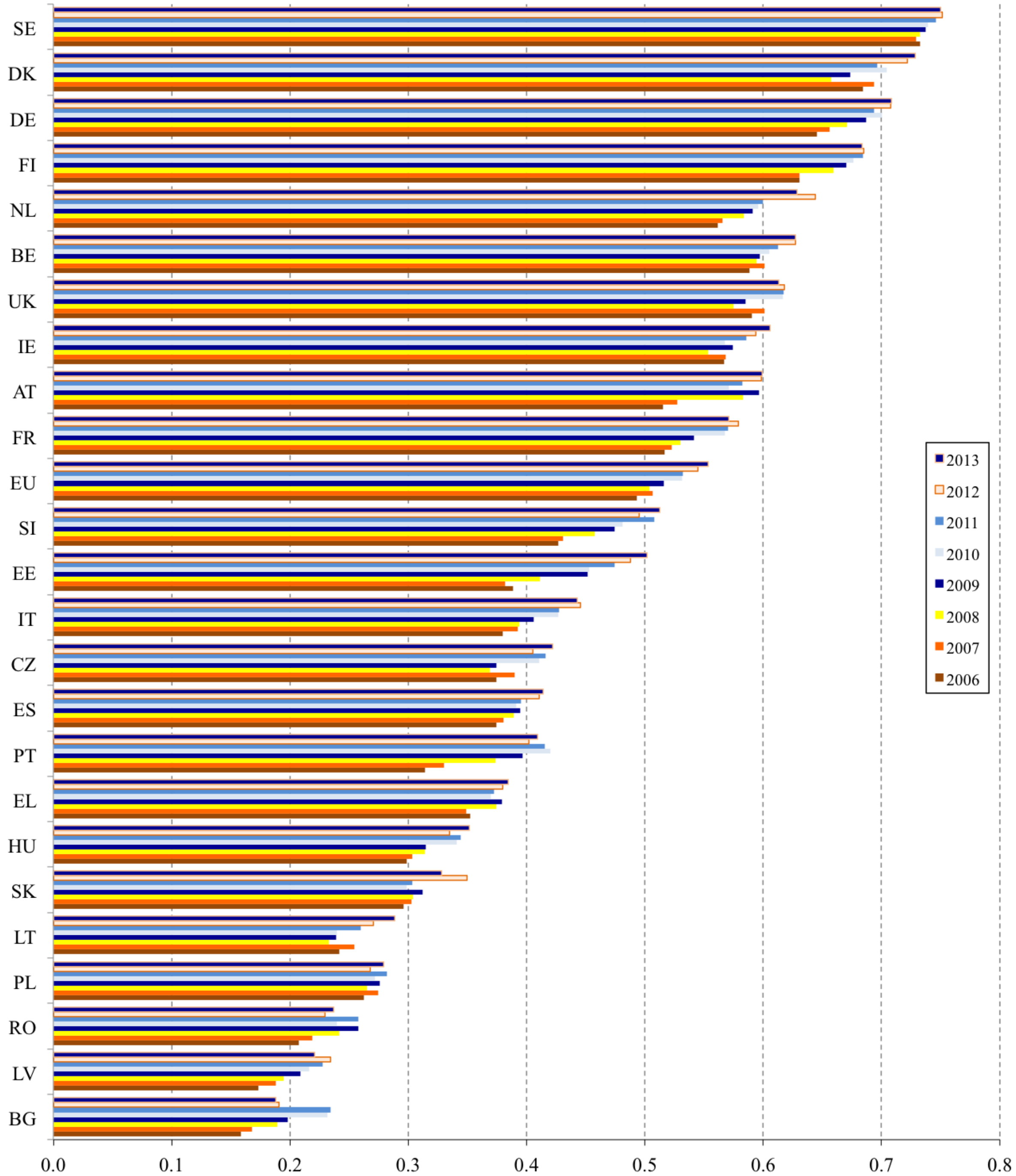
x: mainly relevant

b: relevant for both types

Source: adapted from Havas (2015b), extended version

In spite of this bias, the SII is a widely used tool by analysts, experts and policy-makers. Thus it cannot be ignored what it tells about the EU10 countries. By considering the SII in 2006-2013, two major observations can be drawn. First, by this metrics the EU10 countries are grouped more closely together than by several other ('individual') indicators used in this paper. None of the EU10 countries is among the top 10 innovation performers, while Ireland, one of the four 'classic' cohesion countries is ranked 8, ahead of Austria and France. The best performers among the EU10 countries are Slovenia (No. 11), Estonia (No. 12), and the Czech Republic (No. 14). The remaining 7 EU10 countries take the bottom 7 positions on Figure 8. Using the IUS classification (and keeping that order), only Slovenia and Estonia are in the group of "innovation followers", the Czech Republic, Hungary, Slovakia, Lithuania and Poland are "moderate innovators", while Romania, Latvia and Bulgaria are "modest innovators".

Figure 8: Summary Innovation Index, selected EU countries, 2006-2013



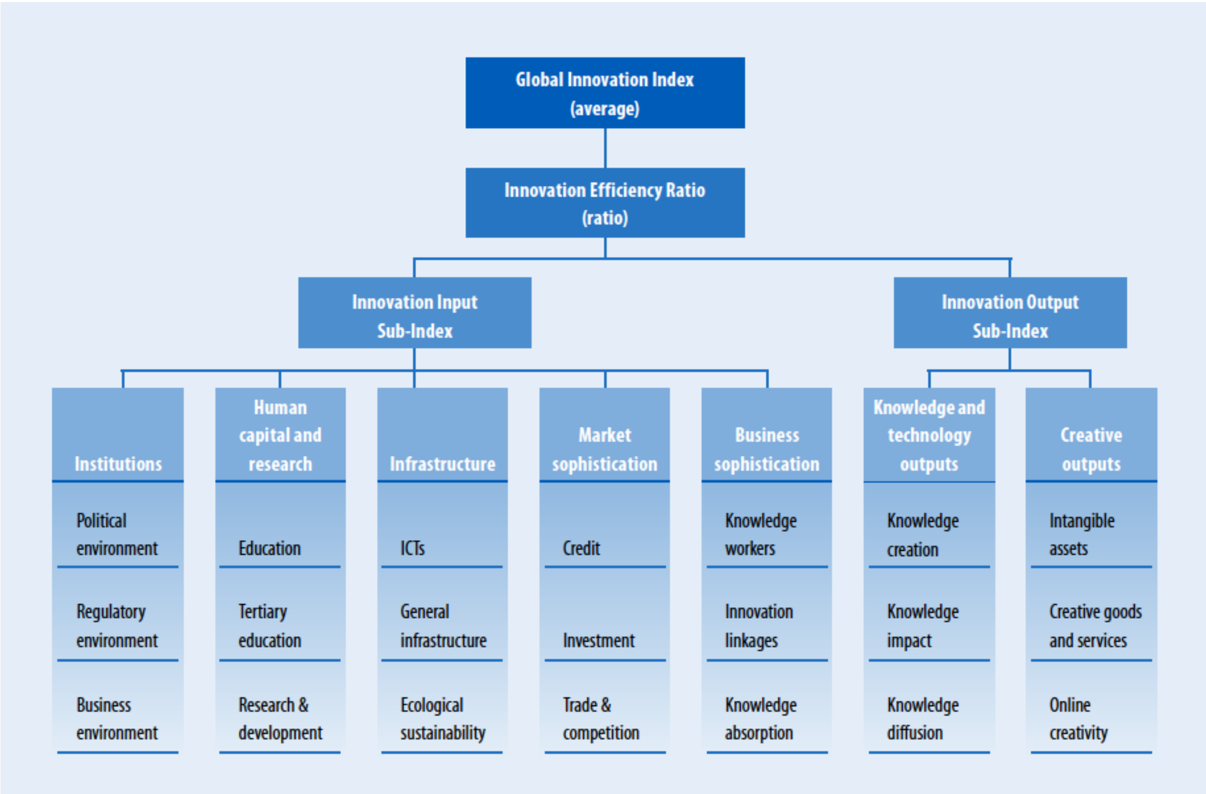
Source: Innovation Union Scoreboard 2014

Second, the dynamics of innovation performance of the EU10 countries, as measured by the IIS, have been diverse since 2006. Eight of the EU10 countries have shown an almost monotonous improvement: the Czech Republic, Estonia, Hungary, Latvia, Lithuania, Romania, Slovakia, and Slovenia. In contrast, an inverted U-shape – that is, an initial improvement followed by falling behind compared to a country's own performance – can be observed in Bulgaria and Romania. Yet, even these latter two countries had a higher SII in 2013 compared to 2006. Estonia recorded the biggest change in absolute terms, that is, 0.114, Slovenia increased its SII by 0.086, the Czech Republic, Hungary, Latvia and Lithuania by 0.047-0.053, Bulgaria, Romania, and Slovakia by 0.029-0.032, while Poland by 0.017. In terms of percentage change, Estonia and Latvia closely followed Portugal, the top EU performer: 29.3%, 27.3%, and 30.4% increase, respectively. Four other countries topped their IIS by 18-20%: Hungary (17.7%), Bulgaria (18.8%), Lithuania (19.5%), and Slovenia (20.2%). The aggregate EU figure increased by 0.06 (a higher rise than in any EU10 countries, except Estonia), or by 12.2% in the same period.

4.4 Global Innovation Index

The Global Innovation Index (GII) has a significantly broader coverage – compared to IUS – in two respects: it covers well over 100 countries, and considers 81 indicators, arranged in 7 "pillars". The seven pillars used in the 2014 edition of the GII include: Institutions (9 indicators), Human capital and research (11), Infrastructure (10), Market sophistication (10), Business sophistication (14), Knowledge and technology outputs (14), and Creative outputs (13). The themes considered by each pillar are summarised in Figure 9.

Figure 9: Framework of the Global Innovation Index 2014



Source: Global Innovation Index 2014

To assess the relevance of these 81 indicators, and especially the 'match' between the themes (or headings) captured by the 7 pillars would go beyond the scope of this paper. In other words, GII results are simply presented here, without assessing their aptness for analytical or policy purposes.

Three EU10 countries have achieved a slight improvement and one kept her position, when comparing their ranking among the EU10 countries and C4 countries: Estonia, the Czech Republic, and Romania have gained 1 place (to No. 2, No. 3, and No. 12, respectively), while Lithuania was ranked 9 in both years. Three countries have been doing even better: Slovenia has become No. 4 from No. 8, and both Latvia and Bulgaria have gained 3 positions (from No. 11 to No. 8, and from being the last to No. 11). In contrast, Hungary has lost 1 position (from No. 6 to No. 7), Poland has become the last from being No. 12, while Slovakia has been doing even worse: from No. 5 to No. 10. (Table 9) As for the C4 countries, Ireland has kept her No. 1 position among these 14 countries; Portugal gained one position, while Greece and Spain both lost 3 places. In an attempt to indicate the overall ranking of the selected 14 countries, they are presented in Table 9 in the order of their cumulative rankings (for instance, that is 7 for Ireland, and 91 for Romania). From that angle, Hungary has shown some non-negligible fluctuation until 2012, while the positions of Estonia, the Czech Republic, Portugal, Lithuania, and Latvia have hardly changed during the 7 years considered.

Table 9: Rankings of the EU10 and C4 countries by the Global Innovation Index, 2007-2014

	2007	2008/2009	2010	2011	2012	2013	2014
Ireland	21 [1]	21 [1]	19 [1]	13 [1]	9 [1]	10 [1]	11 [1]
Estonia	31 [3]	29 [3]	29 [4]	23 [2]	19 [2]	25 [2]	24 [2]
Czech R.	32 [4]	33 [4]	27 [3]	27 [4]	27 [4]	28 [4]	26 [3]
Spain	27 [2]	28 [2]	30 [5]	32 [6]	29 [5]	26 [5]	27 [5]
Slovenia	43 [8]	36 [6]	26 [2]	30 [5]	26 [3]	30 [3]	28 [4]
Hungary	36 [6]	47 [9]	36 [7]	25 [3]	31 [7]	31 [7]	35 [7]
Portugal	39 [7]	40 [7]	34 [6]	33 [7]	35 [8]	34 [8]	32 [6]
Slovakia	35 [5]	35 [5]	37 [8]	37[9]	40 [10]	36 [10]	37 [10]
Latvia	50 [11]	60[12]	44 [10]	36 [8]	30 [6]	33 [6]	34 [8]
Lithuania	47 [9]	42 [8]	39 [9]	40 [10]	38 [9]	40 [9]	39 [9]
Bulgaria	81 [14]	74 [14]	49 [13]	42 [11]	43 [11]	41 [11]	44 [11]
Poland	56 [12]	56 [11]	47 [12]	43 [12]	44 [12]	49 [12]	45 [14]
Greece	49 [10]	54 [10]	46 [11]	63 [14]	66 [14]	55 [14]	50 [13]
Romania	62 [13]	69 [13]	52 [14]	50 [13]	52 [13]	48 [13]	55 [12]
No. of countries	107	130	132	125	141	142	143

Source: Global Innovation Index, various editions, and own calculations

Note: [n] denotes the ranking of a given country among the EU10 and C4 countries

5 Business-academia co-operation in the EU10 countries

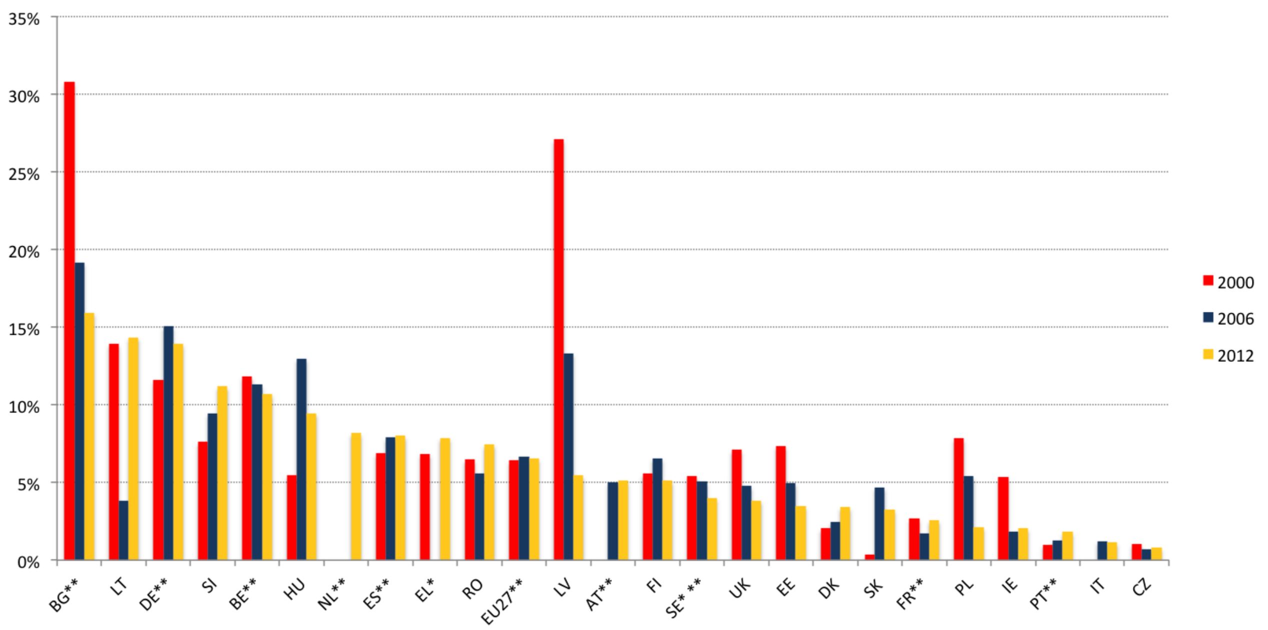
There are a variety of linkages in a successful NIS among its players (businesses, academia, intermediary organisations, service providers, policy-makers etc.). Firms are involved in different ways and to a varying degree in shaping STI policy strategies and actual policy measures. The types and quality of links between businesses and intermediary organisations (including actors offering funds for innovation activities) also influence the performance of a given NIS, just as external linkages, that is, the internationalisation of research, technological development and innovation (RTDI) processes and the impacts of external STI policies. Of these linkages, only business-academia (B-A) co-operation is discussed in this section. It is aimed at providing a map of business-academia collaboration in the EU countries, with a special emphasis on the EU10 countries, drawn by using several 'lenses' offered by various data sets.

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

While at the EU27 level 6.3-6.8% of HERD (higher education R&D expenditures) was financed by businesses in 2000-2012, at a country level one can find much more variation both in terms of the ratio of business sources and dynamics. (**Figure 10**) The share of business sources in funding HERD was around or above 10% in 6 countries, around 7-8% in 4 countries, 3-5% in 8 countries, and less than 3% in 6 ones in 2012. In some countries this share decreased significantly, e.g. from 30.8% in 2000 to 16.0% in 2012 (BG), or from 27.1% to 5.4% (LV). Overall, this share grew in 10 countries by 2012, among these by around 4 percentage points in Hungary and Slovenia, and by 2.3 percentage points in Germany from an already high level, while declined in 11 countries (missing data for 3 countries).

The share of business sources in funding HERD is higher than the aggregate EU27 figure in 10 countries, of which *5 are new member states* and one is a less developed Southern European country. The relatively high ratio of business funding in these countries might be attributed to the low amount of HERD in absolute terms: a few projects commissioned by firms, with relatively low budgets by international standards, can lead to a high weight of business funding in HERD.

Figure 10: Share of businesses in funding HERD, EU countries, 2000, 2006, 2012 (%)



Source: compiled by using Eurostat data

** 2001 data instead of 2000 data*

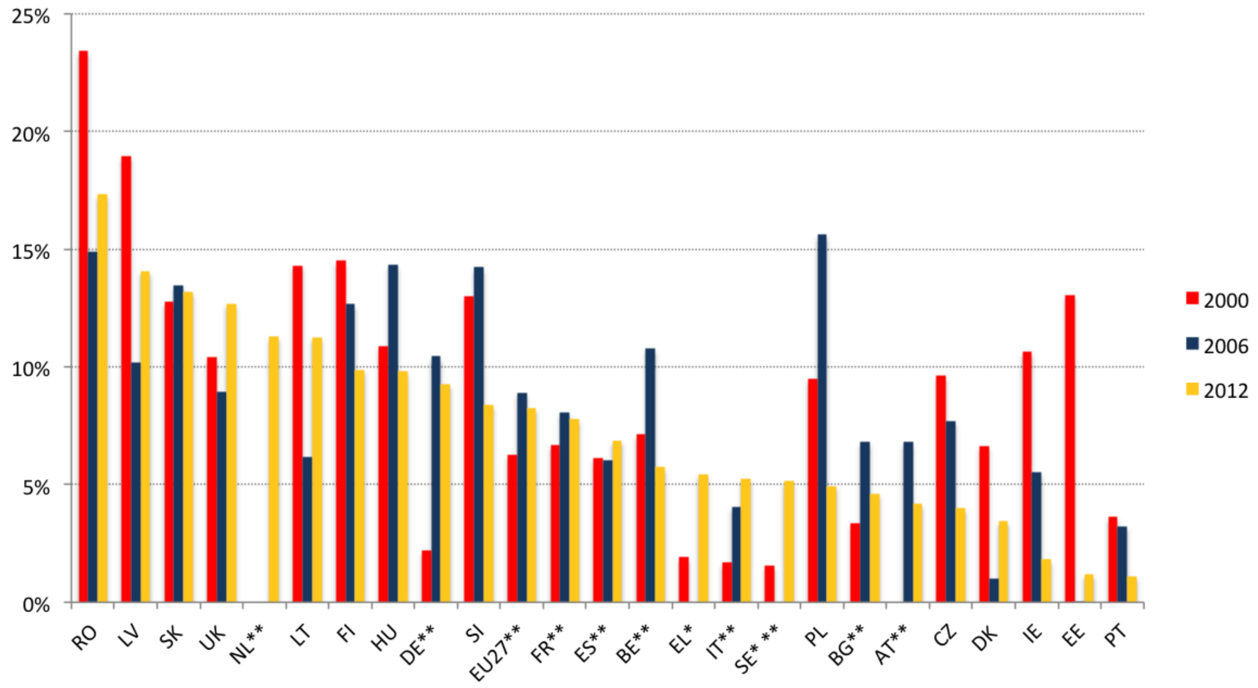
*** 2011 data instead of 2012 data*

Note: Data for Cyprus, Luxembourg and Malta are not included in this figure.

The share of business sources in funding Government Intramural Expenditure on R&D (GOVERD) was 5.7-8.9% at an aggregate EU27 level in 2000-2012. As for the member states, this ratio was in the range of 1.1% (PT [2011]) and 17.3% (RO) in 2012. (**Figure 11**)

The share of GOVERD financed by businesses is higher in 10 member states than the EU27 figure, and *6 of these are new members*. The low volume of GOVERD in these countries, most likely, is an important factor in explaining the high value of this ratio.

Figure 11: Share of businesses in funding GOVERD, EU countries, 2000, 2006, 2012 (%)



Source: compiled by using Eurostat data

** 2001 data instead of 2000 data*

*** 2011 data instead of 2012 data*

Note: Data for Cyprus, Luxembourg and Malta are not included in this figure.

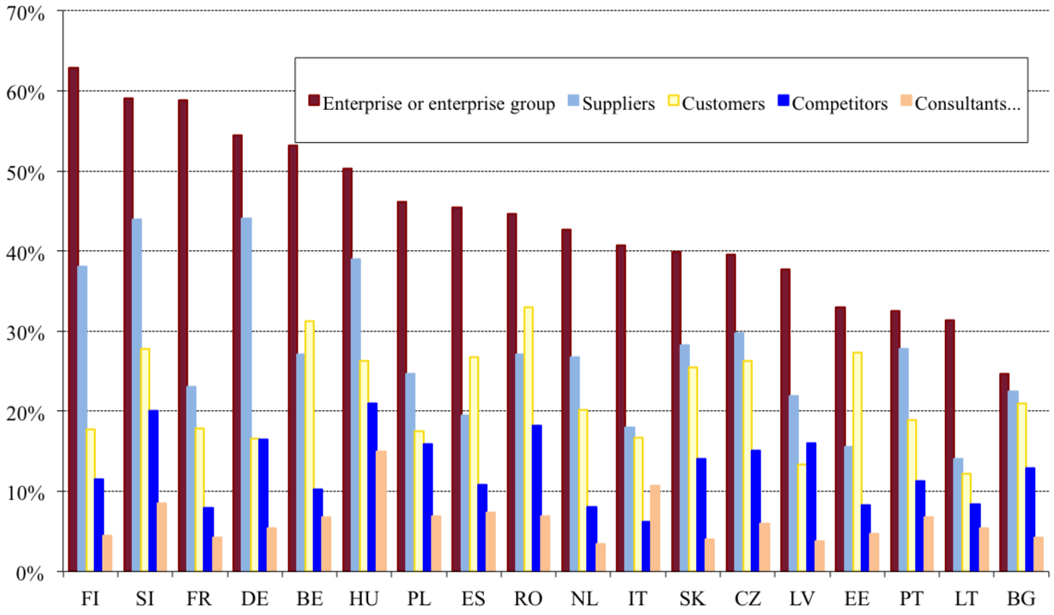
5.2 Information sources for innovation

The quality of co-operation among the NIS players can be characterised by firms' assessments as to the importance of sources of information for their innovation activities. In all countries participating in CIS 2008 and CIS 2010 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 Figures 12-14 only present these business-type sources of information. Overall, no major change can be observed in the three periods considered here in terms of the difference among of countries. Customers, however, became the second most important sources of information in 10 countries (of 16 ones) in 2008-2010, compared to 4 countries (of 18 countries) in 2006-2008. That trend was further strengthened in 2010-2012 with 14 countries (of 19 ones) where customers were considered as the second most important sources of information. Moreover, in Romania almost half of the respondents appreciated customers as a highly important source of innovation, and thus customers were ranked No. 1.[25]

The EU10 countries are 'scattered': (i) they neither show a particular pattern in terms of the importance of the various sources of information; and (ii) nor are grouped closely together. In all the three periods Slovene firms highly appreciated internal sources of information, together with suppliers and customers,

[25] It should be added, however, that a distinction between customers from the private vs. public sector was introduced in this period, and 32.9% of Romanian respondents regarded customers from the public sector as a highly important source of innovation, while 13.6% of them did so concerning customers from the private sector.

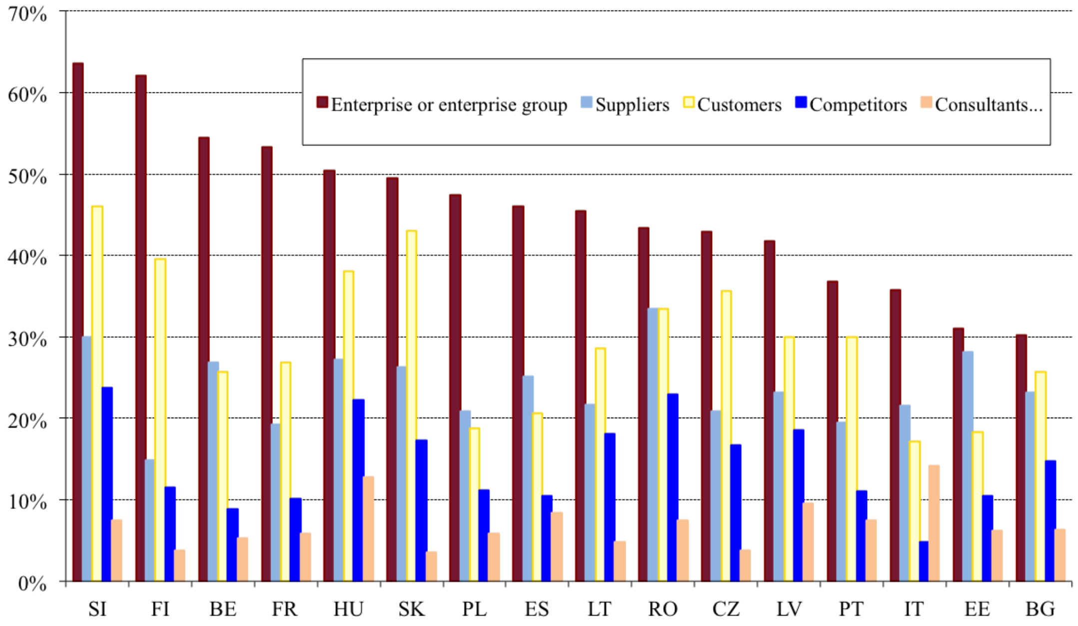
Figure 12: Highly important 'business' sources of information for product and process innovation, EU members, 2006-2008



Source: Eurostat, CIS 2008

Note: Data for Cyprus, Luxembourg and Malta are not included in this figure.

Figure 13: Highly important 'business' sources of information for product and process innovation, EU members, 2008-2010

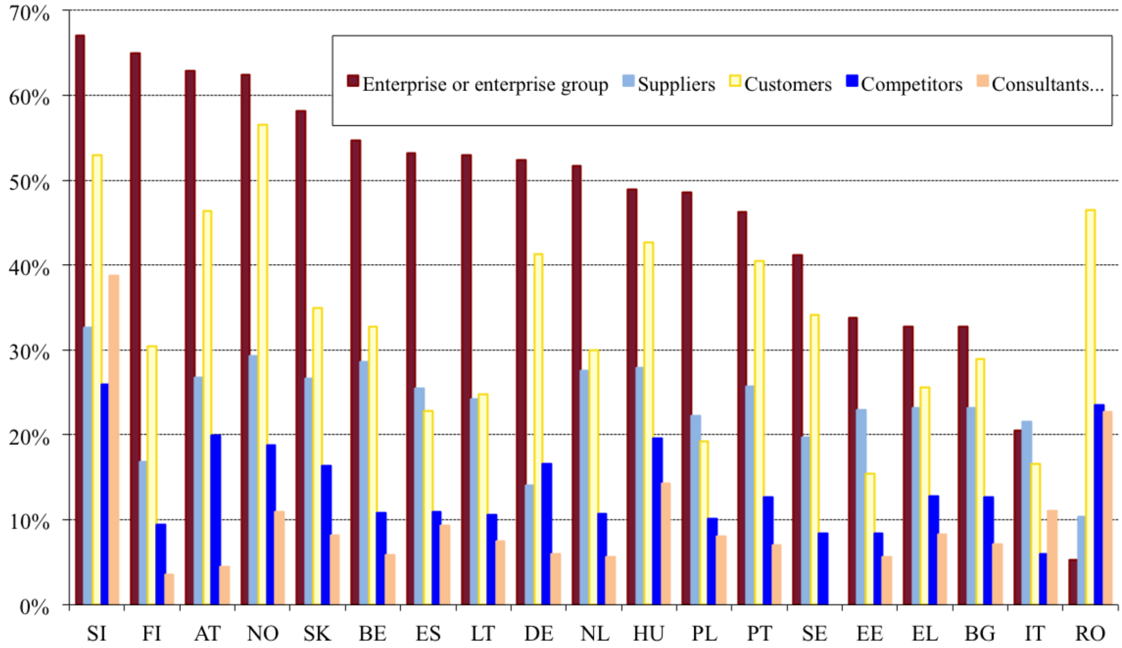


Source: Eurostat, CIS 2010

Note: Data for Cyprus, Luxembourg and Malta are not included in this figure.

while their counterparts in the Baltic states and Bulgaria were less 'impressed'. More detailed analyses would be needed to establish if these dissimilarities are due to cultural differences (managers are more 'enthusiastic', more generous in appreciating sources of information in Slovenia compared to the Baltic states and Bulgaria) or can be attributed to a genuine difference in terms of the usefulness of information sources. Noticeable changes can be observed in two EU10 countries: a markedly higher share of Lithuanian and Slovak firms regarded these sources of information as highly important in 2008-2010 than in 2006-2008. These higher figures were recorded in 2010-2012, too. As cultural changes usually take longer than 2-3 years, perhaps these data – together with the overall higher appreciation of customers as sources for information, noted above – suggest that respondents' replies do indicate the usefulness of various information sources.

Figure 14: Highly important 'business' sources of information for product and process innovation, EU members, 2010-2012



Source: Eurostat, CIS 2012

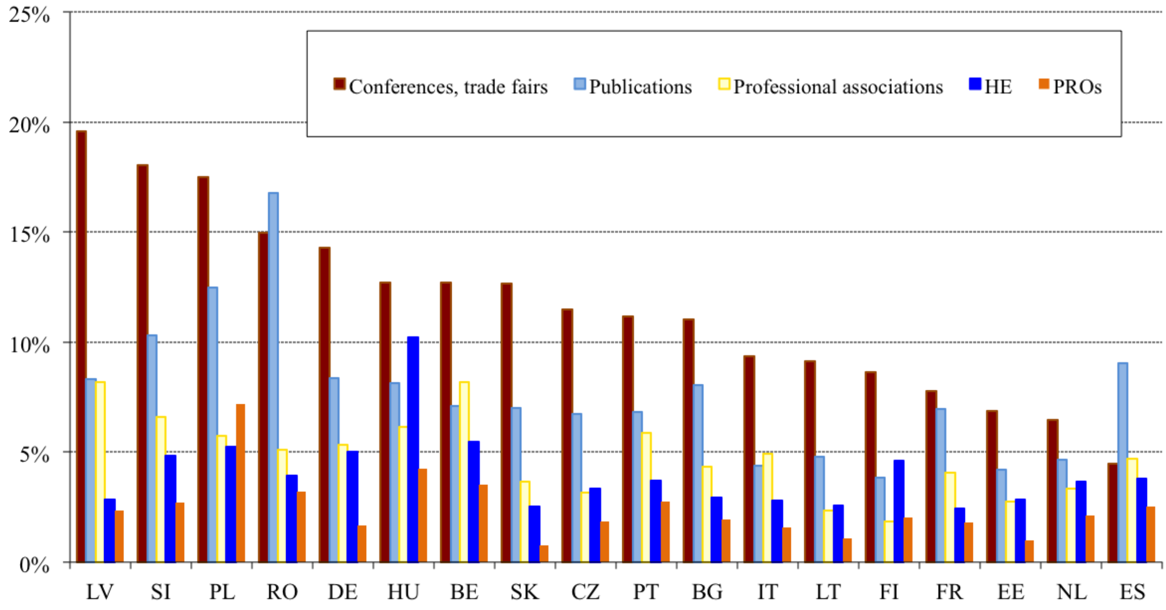
Note: Data for Cyprus, Luxembourg and Malta are not included in this figure.

The other sources of information for innovation – which can be called 'scientific' ones in a bit simplified way – are depicted on Figures 15-17. 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 come second, followed by universities and public research institutes. No major change can be observed in this respect when comparing the periods considered here.

In the first two periods *a larger share of the EU10 respondents* gave a high esteem to these sources of information compared to their counterparts in the more advanced EU members, with the exceptions of Germany and Belgium in 2006-2008. German data are not available for 2008-2010, and Belgian firms became somewhat more 'reserved' in that period. It should be added, that data for Austria, Denmark, Sweden, and the UK are not available for these two periods, and Dutch data only cover 2006-2008. Data are available for 19 countries for 2010-2012 (as opposed to 16 in 2008-2010). This larger sample includes Austria and Sweden (although only for one source of information), as well as the Netherlands (after a 'pause' in 2008-2010), and it shows a more varied picture: EU10 and other countries are 'alternating' on the horizontal axis of

Figure 17. Thus an apparently marked difference between the EU10 countries and the more advanced member states has to be taken with a pinch of salt.

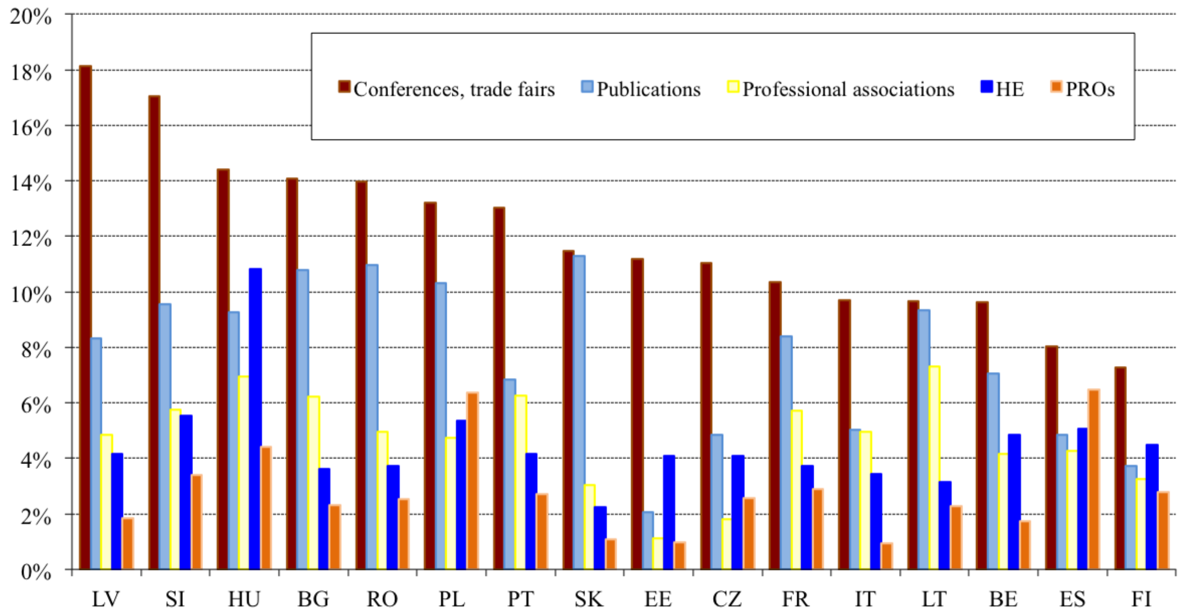
Figure 15: Highly important 'scientific' sources of information for product and process innovation, EU members, 2006-2008



Source: Eurostat, CIS 2008

Note: Data for Cyprus, Luxembourg and Malta are not included in this figure.

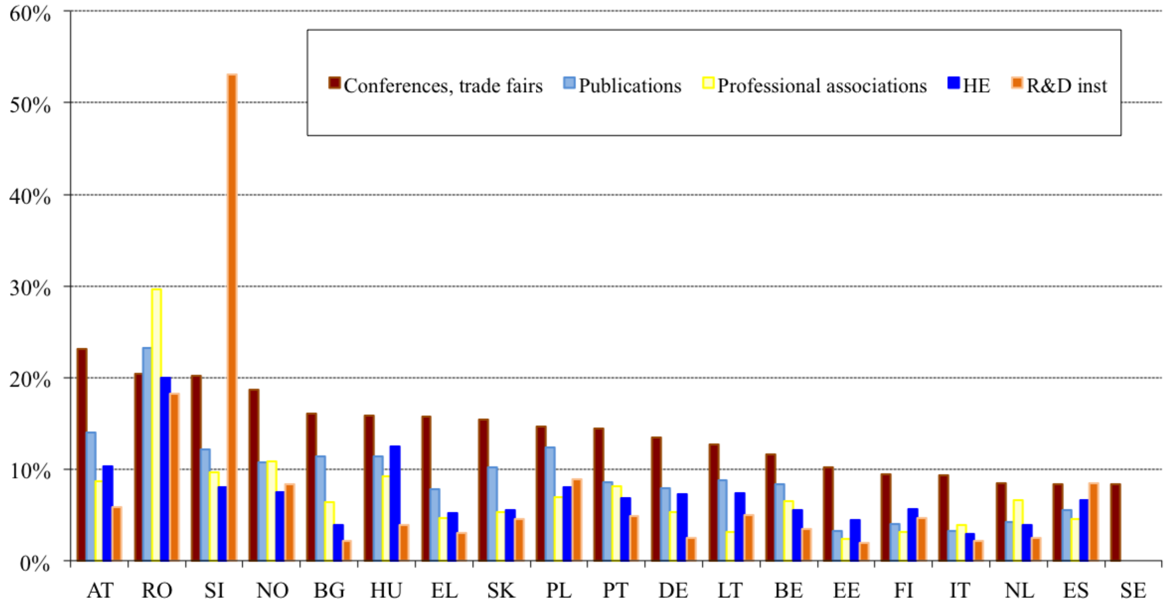
Figure 16: Highly important 'scientific' sources of information for product and process innovation, EU members, 2008-2010



Source: Eurostat, CIS 2010

Note: Data for Cyprus, Luxembourg and Malta are not included in this figure.

Figure 17: Highly important 'scientific' sources of information for product and process innovation, EU members, 2010-2012



Source: Eurostat, CIS 2010

Note: Data for Cyprus, Luxembourg and Malta are not included in this figure.

Table 10: The share of innovative firms regarding universities as highly important source for innovation (%), and the rank of universities among the 5 "scientific" sources of information ([n])

	2006-2008	2008-2010	2010-2012
Romania	3.9 [4]	3.7 [4]	20.0 [3]
Hungary	10.2 *[2]*	10.8 *[2]*	12.5 *[2]*
Austria	n.a.	n.a.	10.3 [3]
Poland	5.3 [4]	5.4 [3]	8.0 [4]
Slovenia	4.8 [4]	5.5 [4]	8.0 [5]
Norway	n.a.	8.5 [5]	7.5 [5]
Lithuania	2.6 [3]	3.1 [4]	7.4 [3]
Germany	5.0 [4]	n.a.	7.3 [3]
Portugal	3.7 [4]	4.2 [4]	6.8 [4]
Spain	3.8 [4]	5.1 [3]	6.6 [3]
Finland	4.6 *[2]*	4.5 *[2]*	5.6 *[2]*
Belgium	5.5 [4]	4.9 [3]	5.5 [4]
Slovakia	2.5 [4]	2.2 [4]	5.5 [3]
Greece	n.a.	n.a.	5.2 [3]
Estonia	2.8 [3]	4.1 *[2]*	4.4 *[2]*
Latvia	2.9 [4]	4.2 [4]	n.a.
Czech Republic	3.4 [3]	4.1 [3]	n.a.
Bulgaria	2.9 [4]	3.6 [4]	3.9 [4]
the Netherlands	3.6 [3]	n.a.	3.9 [4]
Italy	2.8 [4]	3.4 [4]	2.9 [4]
France	2.4 [4]	3.7 [4]	n.a.

Source: Eurostat, the respective rounds of CIS

Note: Countries are listed by their 2010-2012 data (or by 2008-2010 data when more recent ones are not available).

It is worth digging a bit deeper to explore whether the EU10 countries give a higher esteem to scientific sources of innovation compared to other EU members states[26] (especially the most advanced ones) by narrowing down our analysis to two sources of information: universities and public research organisations.[27]

At least 8% of firms regarded universities as highly important sources of information in 5 countries, of which 4 are in the group of EU10 countries. By far the biggest jump occurred in Romania: from 3.7% in 2008-2012 o 20.0% in 2010-2012. In another 5 of the EU10 countries this ratio was in the range of 4.0-5.5%, and thus these countries are closer to the bottom of this 'scoreboard'. (Table 10) Universities were among the top 3 "scientific" sources of information in seven countries in 2008-2010: they came second in Estonia, Finland, and Hungary, while third in Belgium, the Czech Republic, Poland, and Spain. The respective figures for 2010-2012 are as follows: universities ranked No. 2 in the same three countries, and No. 3 in Austria, Germany, and Greece (no data for these countries in 2008-2010), as well as in Lithuania, Romania, and Spain (again).

Table 11: The share of innovative firms regarding research institutes as highly important source for innovation (%), and the rank of research institutes among the 5 "scientific" sources of information ([n])

	2006-2008	2008-2010	2010-2012
Norway	n.a.	10.4 [4]	8.4 [4]
Spain	2.5 [5]	6.5 [2]	8.5 [1]
Poland	7.2 [3]	6.4 [3]	8.9 [3]
Austria	n.a.	n.a.	5.8 [5]
Hungary	4.2 [5]	4.4 [5]	3.9 [5]
Slovenia	2.7 [5]	3.4 [5]	53.1 [1]
Greece	n.a.	n.a.	3.0 [5]
France	1.8 [5]	2.9 [5]	n.a.
Finland	2.1 [4]	2.8 [5]	4.7 [3]
Portugal	2.8 [5]	2.7 [5]	4.9 [5]
Czech Republic	1.9 [5]	2.6 [4]	n.a.
Romania	3.2 [5]	2.5 [5]	18.2 [5]
Germany	1.7 [5]	n.a.	2.5 [5]
the Netherlands	2.1 [5]	n.a.	2.5 [5]
Bulgaria	2.0 [5]	2.3 [5]	2.2 [5]
Lithuania	1.1 [5]	2.3 [5]	5.0 [4]
Latvia	2.4 [5]	1.8 [5]	n.a.
Belgium	3.5 [5]	1.7 [5]	3.5 [5]
Slovakia	0.8 [5]	1.1 [5]	4.5 [5]
Estonia	1.0 [5]	1.0 [5]	1.9 [5]
Italy	1.6 [5]	0.9 [5]	2.2 [5]

Source: Eurostat, the respective rounds of CIS

Notes: The category of research institutes included "Government or public research institutes" in 2006-2008 and 2008-2010, and then it changed into "Government, public or private research institutes" in 2010-2012. Countries are listed by their 2008-2010 data.

[26] Norway is also included in this sample.

[27] The full names of the various sources clearly show that only these two are truly scientific ones; all the others have business-type components, too: "Conferences, trade fairs, exhibitions"; "Scientific journals and trade/technical publications"; "Professional and industry associations".

The EU10 countries and the other EU member states[28] are more 'evenly' distributed in Table 11 on the one hand, and in the case of 16 countries there is no major difference among them, on the other: the share of innovative firms regarding publicly financed research institutes as highly important source for innovation was fairly low, that is, in the range of 0.9-3.4% in 2008-2010.

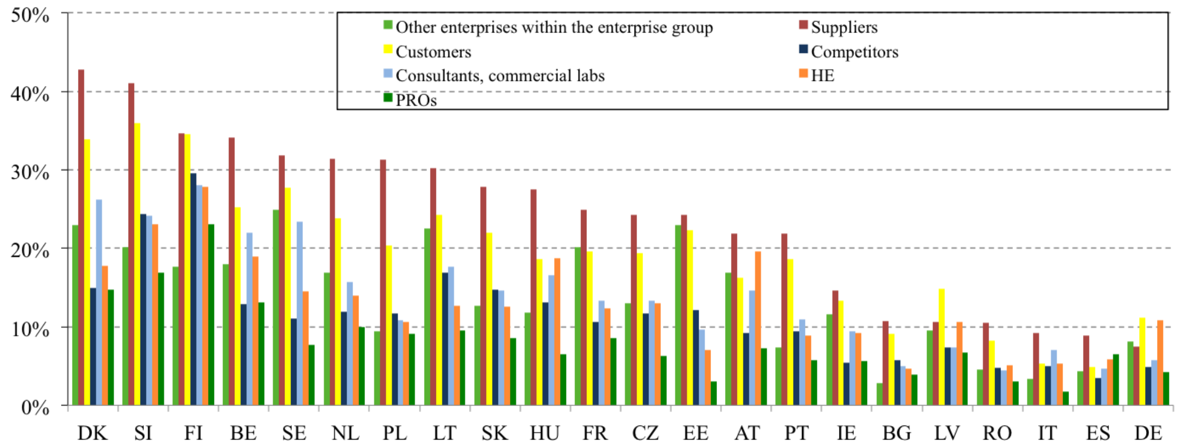
Government or public private research institutes ranked No. 2 in Spain, while in all other countries No. 5, except Poland (No. 3), and the Czech Republic (No. 4) in 2008-2010.

5.3 Innovation co-operation methods

Several factors influence innovation processes and performance and the frequency and quality of co-operation is certainly among those factors. Thus, when analysing B-A co-operation the frequency with which these various methods are used is an important piece of information. Further, it is also essential to note which co-operation method is the most valuable one for firms. Noteworthy changes have occurred in these respects in the three periods considered here, and thus these developments are analysed separately below.

The largest share of innovative firms indicated innovation cooperation with their suppliers in all EU members participating in the CIS 2008 survey, except Latvia and Germany, where customers were the most sought-after partners. Yet, the frequency of these co-operations was wide-ranging: from 7% (Germany) to 43% (Denmark). Customers were the second most frequently chosen partners in 20 countries (in Finland, the difference between suppliers and customers was a mere 0.15 percentage points). The overall frequency of innovation co-operations was lower in the EU10 countries in 2006-2008 than in the more advanced EU members, with two puzzling exceptions, namely Austria and Germany. (Figure 18)

Figure 18: Innovation co-operation methods, EU members, 2006-2008



Source: Eurostat, CIS 2008

Note: Data for Cyprus, Luxembourg and Malta are not included in this figure.

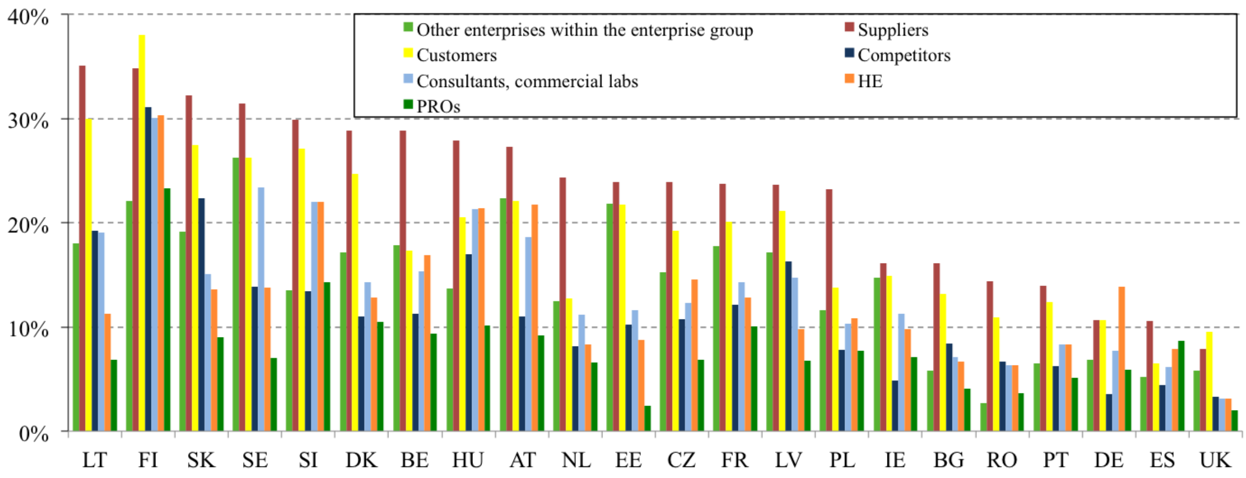
Similarly to the previous period, in 2008-2010 the highest share of innovative firms almost in all EU countries reported co-operation with suppliers, with the exception of Finland and the UK (where customers were the top co-operation partners), and Germany (HEIs). It is noteworthy that 23-35% of the innovative firms co-operated with suppliers in 15 countries, and 16% of them did so in another 2 countries, while the aggregate EU27 figure was 15.2%. Similarly, 21-30% of the innovative firms co-operated with clients or

[28] Again, Norway is also included in this sample.

customers in 14 countries, and 13-15% of them did so in another 3 countries, while the aggregate EU27 figure was 12.6%. As for competitors or other enterprises in the sector, 8-31% of the innovative firms in 14 countries co-operated with them, as opposed to 6.7% at the EU27 level. Finally, 12-26% of the innovative firms in 16 countries co-operated with other enterprises within the enterprise group, which was well above the EU27 figure (9.3%). In short, innovation co-operation with 'business' partners was much more widespread in a large number of countries than suggested by the aggregate EU27 data. (Figure 19)

In this period there was *no clear division between the more and the less advanced member states* (or the ones belonging to various groups defined using the Summary Innovation Index). For example, Lithuania, Slovakia and Slovenia are next to Finland, Sweden and Denmark on Figure 19, while Bulgaria and Romania are in the same group as Germany, Spain and the UK.[29] In other words, the higher occurrence of innovation co-operation does not seem to be a decisive factor on its own: it does not necessarily mean a better innovation – and ultimately economic – performance.

Figure 19: Innovation co-operation methods, EU members, 2008-2010



Source: Eurostat, CIS 2010

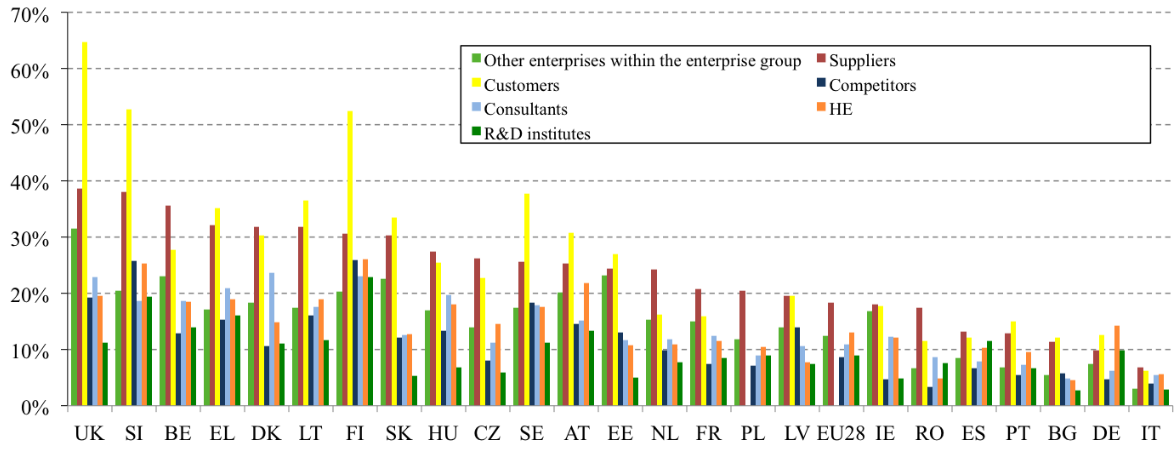
Note: Data for Cyprus, Luxembourg and Malta are not included in this figure.

In 2010-2012 the frequency of innovation co-operation increased to a significant extent in several countries. Customers became not only more sought-after partners compared to 2008-2010, but they were the most frequently mentioned ones in 10 countries, and in another 4 countries they were neck and neck with suppliers. Further, customers were No. 2 partners in 9 countries. From a different angle, suppliers lost their clear 'lead' observed in the previous two periods, and were the most frequently mentioned partners in 9 countries, and No 2 partners in 10 countries. Except Poland, customers and suppliers were the top 2 co-operation partners in the EU10 countries, too. (Figure 20) For this period, customers from the private vs. public sector were distinguished: the latter ones were especially frequently mentioned partners – that is, the share of customers from the public sector was at least 44% of the share of those from the privates sector – in 13 countries, including 5 of the EU10 countries, as well as 5 fairly advanced countries. (This distinction, however, does not appear on Figure 20.)

[29] Lithuania, Bulgaria and Romania were in the group of "modest innovators" given their 2008-2009 performance, reflected in the Innovation Union Scoreboard 2010, Slovakia and Spain were among the "moderate innovators", Slovenia and the UK were "innovation followers", while Denmark, Finland, Germany Sweden formed the club of "innovation leaders". (UNU-MERIT, 2011)

Again, there was *no clear division between the more and the less advanced member states* (or the ones belonging to various groups defined using the Summary Innovation Index). For example, Slovenia is next to the UK, Belgium and Denmark, while Lithuania, Hungary, the Czech Republic, and Slovakia are close to Finland, Sweden, and Austria on Figure 20, while Bulgaria is in the same group as Germany, Spain, and Italy.

Figure 20: Innovation co-operation methods, EU members, 2010-2012



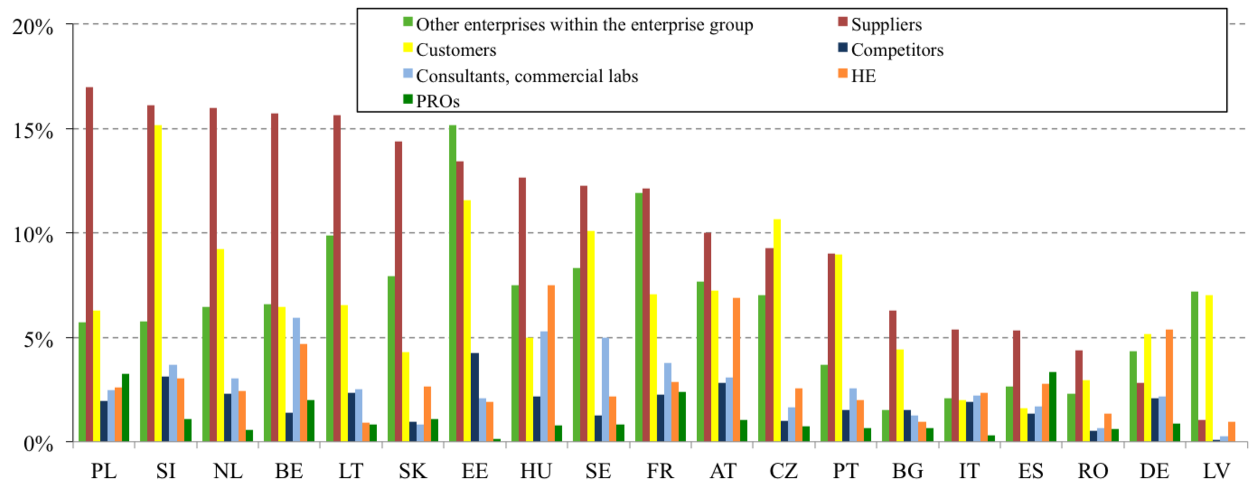
Source: Eurostat, CIS 2012

Note: Data for Cyprus, Luxembourg and Malta are not included in this figure.

In most EU countries 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. (Figures 21-23)

Co-operation with higher education institutes was among the top three methods only in three countries in 2006-2008: HEIs were ranked first in Germany (5.4% of the innovative firms mentioned this method as the most valuable for innovation, and 5.2% perceived customers as the most valuable innovation co-operation partners), and second in Spain (2.8%) and Hungary (7.5%, in these two countries neck and neck with other enterprises within the enterprise group). PROs are assessed far less favourably: besides Spain, where they were ranked No. 2 (3.3%), nowhere else they were among the top 3. (Figure 21)

Figure 21: Innovation co-operation methods assessed most valuable, EU members, 2006-2008

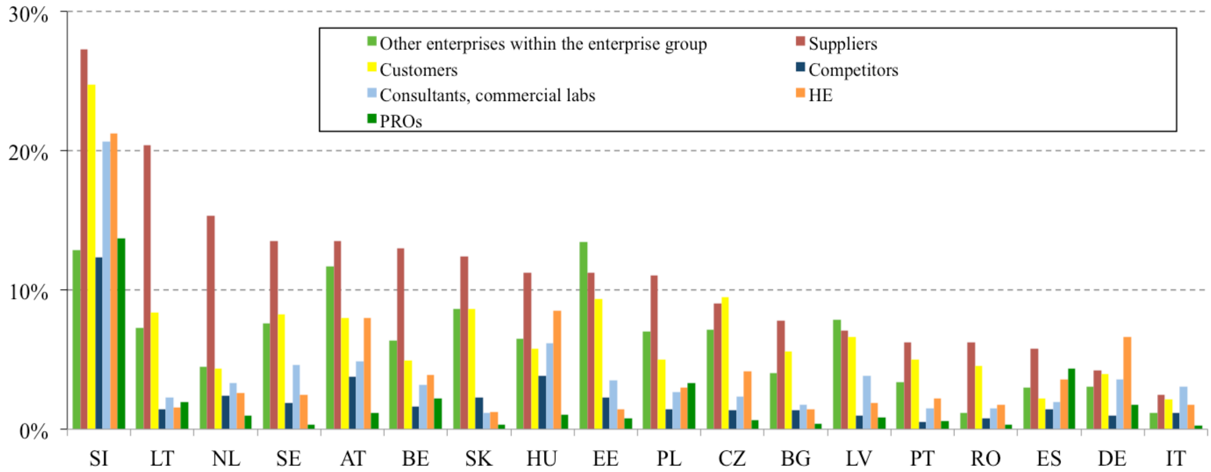


Source: Eurostat, CIS 2008

Note: Data for Cyprus, Luxembourg and Malta are not included in this figure.

HEIs were assessed significantly more favourably in 2008-2010; co-operation with them was among the top three methods in six countries. HEIs were ranked first in Germany (6.6%, followed by suppliers with 4.2%), second in Hungary (8.5%), while third in Austria (8.0%), Romania (1.7%), Slovenia (21.3%), and Spain (3.6%).[31] PROs were approved by a far lower share of innovative firms: in Spain they were again ranked No. 2 (4.3%), but in no other country they made into the top 3. (Figure 22)

Figure 22: Innovation co-operation methods assessed most valuable, EU members, 2008-2010

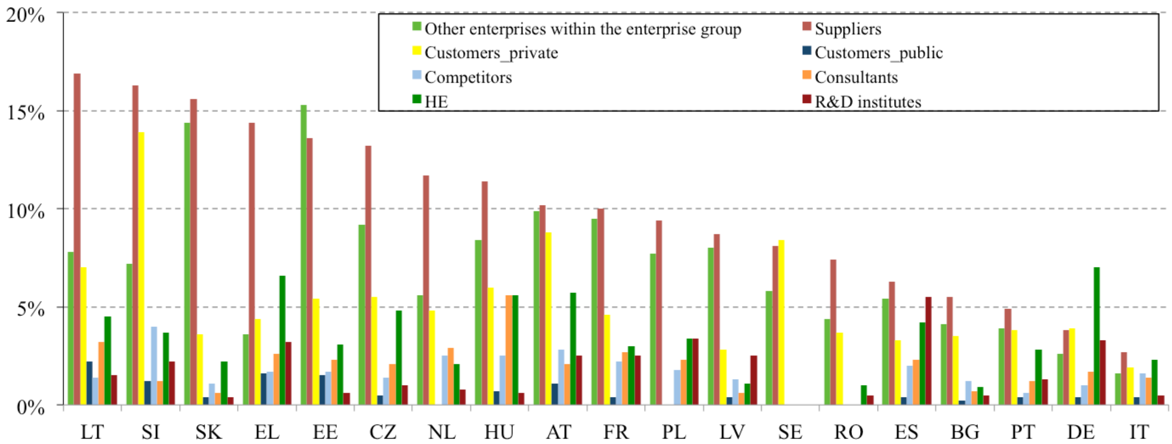


Source: Eurostat, CIS 2010

Note: Data for Cyprus, Luxembourg and Malta are not included in this figure.

As for 2010-2012, HEIs were among the top 3 co-operation partners in four countries, that is, in Germany (No. 1 with 7.0%), Greece (No. 2; 6.6%), Poland (No. 3; 3.4%), and Italy (No. 3; 2.3%).[32] Research institutes, although in this period private ones were also included in this category, were among the top 3 co-operation partners only in Poland and Spain. (Figure 23)

Figure 23: Innovation co-operation methods assessed most valuable, EU members, 2010-2012



Source: Eurostat, CIS 2012

Note: Data for Cyprus, Luxembourg and Malta are not included in this figure.

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[31] These figures also indicate that either only a small number of firms reply to this question of the CIS questionnaire in several countries, and thus with a low share of 'votes' universities can take one of the top three positions, or the respondents in some countries are more critical when the value of innovation co-operation methods is to be assessed than in other countries.

[32] Hungary can also be mentioned where HEIs were very close to the top 3: co-operation with customers from the private sector was mentioned by 6.0% of innovative companies as the most valuable co-operation method, followed closely by that of with consultants and HEIs, both method mentioned by 5.6% of innovative firms.

6 STI policy rationales

6.1 Policy rationales derived from economic theories

Mainstream economics is primarily concerned with *market failures*: unpredictability of knowledge outputs from inputs, inappropriability of full economic benefits of private investment in knowledge creation, and indivisibility in knowledge production lead to a 'suboptimal' level of business R&D efforts. Policy interventions, therefore, are justified if they aim at (a) creating incentives to boost private R&D expenditures by ways of subsidies and protection of intellectual property rights, or (b) funding for public R&D activities.

Evolutionary economics of innovation posits that the success of firms is largely determined by their abilities to exploit various types of knowledge, generated by both R&D and non-R&D activities. Knowledge generation and exploitation takes place in, and is fostered by, various forms of internal and external interactions. The quality and frequency of the latter is largely determined by the properties of a given innovation system, in which these interactions take place. STI policies, therefore, should aim at strengthening the respective innovation system and improving its performance by tackling *systemic failures* hampering the generation, diffusion and utilisation of any type of knowledge required for successful innovation. (Edquist, 2011; Foray (ed.), 2009; Freeman, 1994; Lundvall and Borrás, 1999; OECD, 1998; Smith, 2000) From a different angle, conscious and co-ordinated policy efforts are needed to *promote knowledge-intensive activities in all sectors*. *This lesson is of particular relevance for the EU10 countries.*

6.2 STI policy rationales followed in the EU10 countries

The notion of market or systemic failures is rarely used In STI policy documents in the EU10 countries. Furthermore, the underlying policy rationale is not specified explicitly in policy documents in any other way. It can be observed, however, that STI policy documents – and especially the way of thinking of high-level policy-makers – largely follow the science-push model of innovation. One important indication of this way of thinking is that most policy documents identify 'high-tech' fields of research – the 'holy trinity' of bio-, nano- and info-communication technologies – together with the related manufacturing sectors as their priorities.[31] It is also reflected in several support measures, aimed at promoting scientific excellence. In effect that means trying to push the boundaries of mankind's knowledge by conducting R&D projects in direct competition with advanced, much more affluent countries in those S&T fields where the costs of research are inhibitive – and thus implicitly neglecting high-quality, sound scientific work aimed at solving societal, economic, environmental or other problems, pertinent to a given country or group of countries.[32] Further, the ranking of a given country on the Innovation Union Scoreboard (IUS) is a frequently used point of departure when middle- or long-term STI policy goals are set. As the IUS considers scientific knowledge to be the decisive input in the innovation processes, the EU10 countries – either at an unconscious or conscious level – follow the science-push model of innovation, and thus the market failure argument. It should also be noted, however, that some efforts to correct systemic failures, or from a different angle, to develop innovation systems at national, regional and sector level – can also be detected in various STI

[31] Havas (2015b) points out that various EC and OECD documents and league tables strengthen this way of thinking.

[32] The issue of "excellence vs. relevance" is explored in detail e.g. in Radošević and Lepori (2009).

policy documents. Some experts – working in middle-level positions – are certainly familiar with the systemic view of innovation.

This way of thinking is not unique to the EU10 countries at all. A recent survey, prepared for the European Research and Innovation Area Committee (ERAC) concludes that decision-makers in most EU member states still follow the science-push model of innovation, that is, they focus on the STI mode of innovation when devising policy schemes. (Edquist, 2014a, 2014b)

Certainly it would be a mistake to assume a one-to-one relationship between an economics paradigm and policy practice. In other words, although a certain policy rationale – in the case of STI policies the market failure or the systemic failure argument – can be derived from a given economic paradigm, actual policy measures (or lack of important, supposedly needed policy measures, i.e. those from which favourable impacts can be expected) should not be attributed to a particular school of thought.

No doubt, mainstream economics – or its simplified/ 'vulgarised' version – might have played a prominent role in the formation of STI policies in the EU10 countries in an indirect way. The majority of policy-makers had either studied it at their universities, or heard of it from various – influential – sources. Yet, policy measures are designed by considering several other factors, not only a sound and coherent policy rationale, derived from a theory. These factors include – but not restricted to – political, electoral considerations of the incumbent government; constraints posed by available resources (funds, ideas, policy design and implementation capabilities, etc.); influence by other countries' practices, EC and OECD documents, lobby and pressure groups, NGOs; or – some rare cases in the EU10 countries – consultations with stakeholders.

7 Cluster analysis of STI policy mixes pursued in the EU10 countries

This section[33] reviews the evolution and variety of national innovation policy mixes in the EU (plus Norway and Switzerland) in 2004-2012 using the unique database of research and innovation policy measures built by the ERAWatch and INNO Policy TrendChart initiatives of the European Commission (referred to as 'TrendChart database' hereafter). This database allows us analysing national innovation policy mixes. (Borras and Edquist, 2013; Flanagan et al., 2011; Howlett, 2004) Our investigation is focussing on the policy mix itself. In other words, the issues of policy implementation, the involvement of various actors or the impacts of the so-called framework conditions are not considered here. We capture research and innovation policy instruments to which a financial flow belongs.

The policy mix literature has departed from a focus on single instruments and a single optimal policy model towards the need to understand and address the specific needs and challenges in the innovation system in order to design appropriate mixes of instruments. (Howlett and Rayner, 2007) In principle, an innovation policy mix is dependent on the socio-economic political and historical context of the given country where it is applied. It can be also reasonably assumed that the technological position of a country should have some effect on its policy mix. For example, countries that are modest innovators according to by the Innovation Union Scoreboard, might share more commonalities in their policy mixes amongst themselves vis-à-vis innovation leaders. They are much more focused on imitation and production capabilities when compared with countries that are innovation leaders whose economic development is much more dependent on knowledge generation at world frontier. In the EU context, policy mixes are likely to reflect strong effects of transnational policy learning and a shared common understanding of what is considered to be the 'best

[33] As already mentioned in the Introduction, this section is an abridged version of Izsak et al. (2014).

practice'. Against this backdrop, we explore if countries at different development levels and maturity of their innovation systems have adopted different innovation policy mixes.

The composition of the innovation policy is influenced, among other factors, by the type of grant schemes, use of indirect measures or demand-side actions, thematic prioritisation, the range and share of public funding, the use of mini-mixes or single individual measures and the delivery mechanisms. The mix of innovation policy instruments usually covers a wide range of policy instruments like R&D support, innovation support services provided through innovation centres, business incubators or science and technology parks, indirect incentives like R&D tax credits and grants for business innovation support.

Understanding the linkages between different innovation policy instruments or between related policies (such as environment or education) is important because they can induce both positive synergies or hinder each other's effects. Policy instruments are widely seen as being substitutable, at least in principle. (Landry and Varone, 2005) Public policy is thus a toolbox from which the optimal tools are (or should be) selected. In this view what ends up in the policy mix' is taken for granted whilst the problem of potential policy interaction is simply a matter to factor into tool selection. The only obstacle to adding policy instruments to the mix is cost.

Finding an optimal policy mix is not a one-time exercise but a continuous process, in which actors adjust their strategies, actions and tools to the dynamics of innovation systems. (OECD, 2010) The design and implementation of innovation policy depends on the extent to which innovation policy instruments are defined, customised and combined into policy mixes that address the 'problems' related to the activities of the system. (Borrás and Edquist, 2013)

Common sense clearly suggests that there is no 'ideal' policy mix model; yet, innovation policies are often influenced too much by "best practices", that is, assuming that context does not matter. No doubt, countries or regions with different preconditions for innovation, networking and innovation barriers need different policies. (Tödtling and Trippl, 2005)

The design of the innovation policy mix could be improved when it is based on policy learning, taking into account the environment where it has to operate. (Malerba, 2009) Hence any innovation policy should be well aligned to the given circumstances, including the size and industrial structure of the country and should be composed of a combination of well-targeted policy instruments if it is to influence innovation processes and performance in a positive way. Thus it is crucial to identify specific policy instruments that can stimulate/ strengthen weak elements of a given innovation system or remove blocking mechanisms. (Hekkert et al., 2007)

It is not straightforward to put in place an effective mix of policies that stimulate learning processes and linkages and that also takes into account possible positive and negative interactions among the selected policy instruments.

7.1 Methodology of the chosen cluster analysis

The parameters of the cluster analysis have been defined by focusing on the composition of the policy mixes. No account has been taken of the level of funding or the technological development of a given country, as the analysis is only concerned with the similarities between the mixes of policy measures.

The objective of the cluster analysis is to form homogenous groups of countries in terms of their policy mix recorded in the TrendChart database. To reduce the number of variables (instruments/ typologies) we have created indices that measure conceptually similar things. We have thus relied on our own assessment in defining the indices instead of a factor analysis given the qualitative nature of the problem and the manageable pool of variables in the TrendChart database. We have done this to fulfil the sample requirements for a cluster analysis. We have used a reviewed classification of the TrendChart research and innovation policy measures and made a pre-selection of the most relevant instruments for further analysis. We have anticipated the following 6 variables: 1) Public R&D including Competitive research and Centres of excellence; 2) Industry-Science Collaboration including Collaborative research, Cluster policies and Competence centres where both industry and academic sector is involved; 3) Knowledge and technology Transfer including Technology transfer and Spin-off measures; 4) Business RDI including direct support to business R&D and business innovation; 5) Tax incentives and 6) Venture capital funds (state-backed). The latter two have been incorporated as binomial variables due to the lack of absolute values across years and countries and variables 1-4 have been calculated as percentage of total RDI funding.[34]

7.2 Country patterns of the innovation policy mix in 2003-2012

The cluster analysis has enabled the identification of groups of countries that follow similar innovation policy strategies, irrespective of differences in their levels of funding or their positions in terms of innovation capacity. Thus, countries, which may be at very different positions in terms of their innovation performances, may be relatively similar in terms of their policy mixes and vice versa.

The results of the cluster analysis for 2004-2008 and 2009-2013 are presented in Figure 24 and

[34] Further important methodological considerations and details are presented in Izsak et al. (2014).

Figure 25, respectively, following a hierarchical cluster application. These so-called dendrograms are used to visualise hierarchical clusters. Each country comprises its own unique cluster at the bottom, and is fusing with other countries as the connections in the dendogram show. The countries that fuse at the lowest dissimilarities (y axis) are the least dissimilar or most alike country pairs. This logic follows for the formation of groups of countries. Depending on their similarity-dissimilarity, groups of countries have been identified.

Figure 24: Policy mix clusters in the 2004-2008 period - hierarchical cluster application dendogram

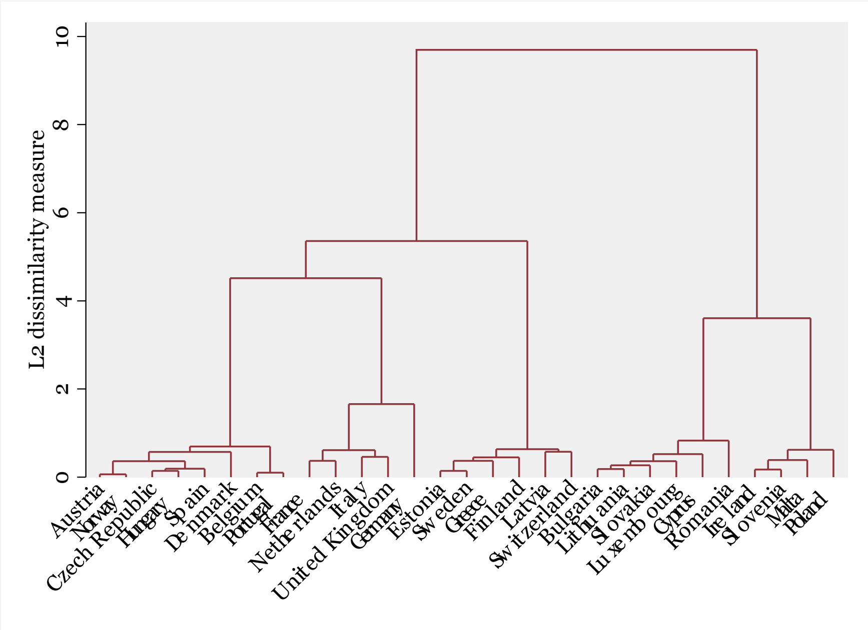
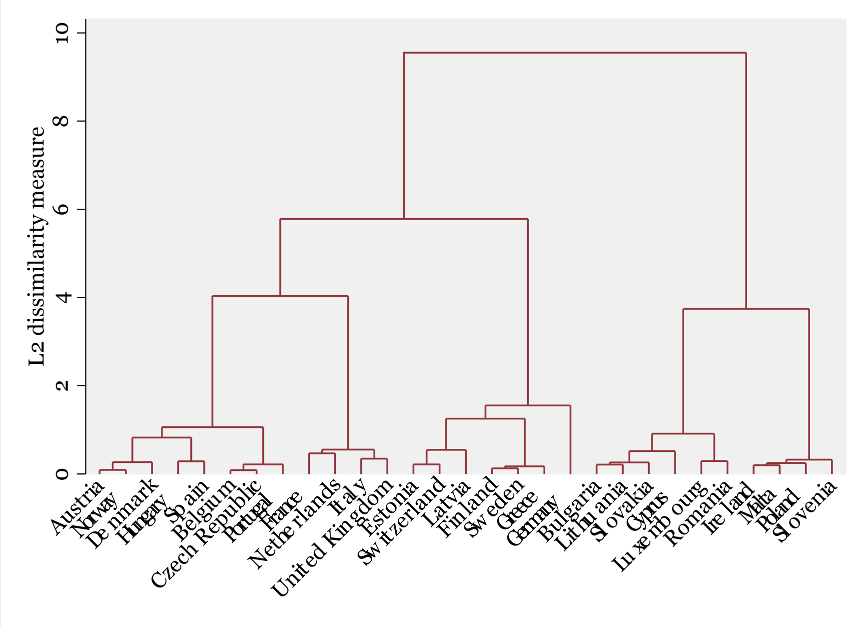


Figure 25: Policy mix clusters in the 2009-2012 period - hierarchical cluster application dendogram



The country patterns point to the relative stability of innovation policy mixes among country groups during the 2004-08 and 2009-12 periods. It is the case despite the fact that there were shifts in terms of countries' funding priorities during the observed periods. These shifts, however, did not alter the key policy mixes and positions of the countries within the groups. In fact, only Germany moved from being a cluster on its own to join cluster 2. The relative stability of policy mixes is quite a robust feature of the EU27 countries, suggesting that policy mixes are shaped either by durable structural features and/or by equally persistent policy philosophies or policy approaches.

Policy learning across the EU has led to the introduction into Member States of similar types of 'fashionable' policy instruments such as cluster policies, competence centres or innovation voucher schemes.[35] In order to more easily grasp the key features of each group, Table 12 provides brief summaries and shorthand labels for each group.

Table 12: Similar policy mix groups and innovation performance within the group as measured by the Innovation Union Scoreboard (IUS) 2013

	Brief description	IUS 2013 performance groups
Group 1 (IE, MT, PL, SI)	Structural Funds-driven; Dual orientation on science and business R&D but with stronger focus on science (competitive R&D) orientation	Innovation followers, Moderate innovators, Modest innovators
Group 2 (EE, FI, DE, EL, LV, SE, CH)	Science and collaborative R&D oriented policy	Innovation leaders, Innovation followers, Moderate innovators, Modest innovators
Group 3 (FR, IT, NL, UK)	Orientation towards commercialisation of public R&D coupled with support to framework conditions (fiscal incentives)	Innovation followers, Moderate innovators
Group 4 (AT, BE, CZ, DK, HU, NO, PT, ES)	Business R&D and innovation focused policy coupled with support to competitive R&D	Innovation followers, Moderate innovators
Group 5 (BG, CY, LT, LU, RO, SK)	Structural funds driven; Dual orientation on science and business R&D but with stronger focus on business R&D orientation	Innovation followers, Moderate innovators, Modest innovators

Notes: The cluster analysis follows the previously outlined logic of capturing policy mix groups across the 27 EU member countries. It has to be noted that even if there are 5 groups identified, it does not mean that the country groups are homogenous. For instance Denmark is further away from the others in Group 4 or Latvia in Group 2.

[35] There has also been diversity in the actual implementation method of these instruments.

Groups 1 and 5 are, by and large, dominated by new Member States. The policy mix of Group 1, which includes Ireland, Malta Poland, and Slovenia, has been driven mainly by competitive R&D funding for projects conducted by universities and research organisations and by using indirect measures such as R&D tax incentives. It includes policy measures that support businesses to innovate and to undertake technological upgrading. In Group 5, with the exception of Cyprus and Luxembourg that are specific cases, the countries are modest (Bulgaria and Romania) and moderate innovators (Lithuania and Slovakia) according to the Innovation Union Scoreboard. They are characterised by weak business R&D and it might be expected that the policy mix would target much more business R&D and innovation. Instead, the major focus is on block funding of R&D, which has remained key to research funding, alongside the parallel introduction of innovation support measures such as consultancy services, cluster support or business innovation support. With a dual orientation on science through activities like centres of excellence and on business R&D, Group 1 is more focused on 'upstream' science, while Group 5 concentrates on business or 'downstream' R&D. A dual focus on both science and business R&D is present in Luxembourg within Group 5, which is a case that deserves further scrutiny.

Group 2 countries are very much focused on collaborative R&D, especially on co-operation between publicly financed research organisations (that includes universities) with businesses. This group shows that a similar policy mix focused on collaborative R&D is present in countries that operate at the technology frontier (Germany, Finland, Sweden and Switzerland), as well as in countries that operate behind the technology frontier (Estonia, Greece, Latvia). In technology leader countries, the focus on collaborative R&D is sensible given their ambition to stay ahead by supporting leading edge business and public R&D. In countries behind the technology frontier, which have very weak business R&D, policy aims to enhance R&D through new technology based firms. In the former group the demand side of R&D is quite well-developed, while in the latter group it is one of the biggest constraints and hence policy attempts to generate pockets of demand for R&D through technology based firms that are closely linked to public sector. This opens a crucial policy questions. Is this orientation is the most appropriate in the case of the latter group? To what extent can policy compensate for the lack in demand for R&D?

Germany, Finland, and Sweden have been increasingly focussing their research and innovation budgets on collaborative R&D programmes and have invested in innovation and technology platforms for academia and industry. Given that their business sectors invest relatively high shares of their revenues in R&D and given their position in relation to technology development, this focus on collaborative R&D appears to be justified. These countries have also dedicated a significant amount of funding to loan-financing and venture capital funds. Yet, they seem to be reluctant to use R&D tax incentives extensively. For instance, the German innovation policy priority has been to support collaboration and cluster policies and followed a strategic approach through its thematic R&D programme. Policy measures have rarely funded single R&D projects in enterprises and R&D tax incentives have not been used given the favourable general taxation policy for businesses.

Group 3 is composed of France, Italy, the Netherlands, and the UK. It is relatively homogenous in terms of policy foci on commercialisation and technology transfer and also with regard to the relevance of indirect policy measures such as tax incentives. In this group, policies aim to capitalise on investments in public R&D by promoting the commercialisation of the results of public R&D, as well as providing tax incentives for R&D investments. The shift towards commercialisation is quite recent (2009-2012); these countries were previously more oriented towards collaborative R&D activities. This may be a result of the increasing pressures in the post-2008 period to generate visible results in order to justify public spending on R&D. These pressures are particularly apparent in the UK.

Group 4 is strongly focused on supporting business R&D and innovation, or in other words, 'downstream' RDI, as well as on competitive R&D. Similarly to Group 2, this policy mix is characteristic of countries that operate closer to the world technology frontier such as Austria, Belgium, Denmark and Norway, as well as of countries that operate further from the technology frontier like the Czech Republic, Hungary, Portugal and Spain. Unlike the new Member States in Group 5, such as Bulgaria, Lithuania, Romania and Slovakia, which are also partly focused on business R&D, this group has significantly higher investments in business R&D and given their technological position, such an orientation might be expected.

8 Discussion and policy implications

8.1 Diversity in structures and structural changes – in spite of unifying external forces

For centuries various external powers had imposed uniformity on certain, very large parts of the territory where the current EU10 states are located. The one, which is most vividly remembered, is the Soviet Union.[36] Thus, observing these countries (or a group of them) from a distance, they certainly used to share major structural similarities and some of those might have long-term repercussions. The 'block' view (the cold war between the East and West) dominated politics and business developments for more than four decades in the second half of the 20th century. Given these legacies (structural features and the level of socio-economic development in the EU10 countries, as well as the dominant way of thinking and discourse since the cold war) Western politicians, business people, analysts and journalists tend to share, and thus reinforce this view of 'uniformity' to some extent even nowadays.[37] Moreover, there is a mild, but noticeable – and certainly understandable – 'drive' also from the academic community to produce findings that can be generalised across the EU10 countries, that is, to focus on identifying shared or similar features and mechanisms. Yet, a closer look at the structure of the national innovation systems in the EU10 countries, as well as at their performance, points to a different direction.

While the structural composition of the research sub-systems of the EU10 countries showed a great diversity already in 2000 – for instance the weight of the business sector in employing FTE researchers was ranging from 4% (Lithuania) to 62% (Romania) and in performing GERD from 21% (Bulgaria) to 56% (Slovenia) –, fairly significant changes have occurred since then almost in all countries, adding more colours to the observed diversity. *Changes have occurred in both directions* (growth and contraction) *in all the three major research performing sectors*, taking either the share of FTE researchers or the portion of GERD performed. Thus *neither a similar structural composition of the research sub-system can be observed, nor a move towards a similar structure*. In other words, *country differences do matter even when one considers a group of countries characterised by broadly similar historical legacies and in the recent past undergoing the transition processes to market economy,* which also brought in some major similar features and necessities.[38]

Several factors might have influenced these restructuring processes, including conscious STI policy efforts, differences in working conditions among the three main research performing sectors, the type and pace of privatisation – in turn, all the political, economic and legal factors influencing privatisation –, structural

[36] Romania and Yugoslavia (and thus the 'predecessor' republic of contemporary Slovenia) used to have special (sometimes no) relationships vis-à-vis the Soviet Union, but their own way of central planning (RO) and the so-called self-management system (YU), as well as their political systems had kept them fairly far away from Western-type of market economies and democracies.

[37] It is not by accident that 8 of the EU10 countries were admitted to the EU in 2004 and the remaining two also joined together in 2007.

[38] The economic performance of the EU10 countries has also been fairly diverse for decades; for the 1995-2015 period, see, e.g. Havlik (2015), as well as the various contributions to WP1 of the GRINCOH project.

changes in the economy, brain drain to other occupations or to foreign countries, fiscal policy, ideological stances vis-à-vis the Academy of Sciences, etc. It is unlikely that a single factor can be identified as a major one. For instance, in the Baltic countries the Academies of Sciences had been largely perceived as part of the Soviet legacy and thus transformed into learnt societies. Yet, the share of the government sector – to which the institutes of Academies used to belong – has been reduced considerably only in Estonia and Lithuania, while increased in Latvia.[39] Similarly, foreign investors have played a major role in privatisation in several countries. In some of those the weight of the business sector in performing R&D activities has increased considerably (e.g. in Estonia, Hungary), while in others that ratio has decreased (e.g. Romania, Slovakia, and the Czech Republic).

8.2 Measuring innovation performance

The principal measurement and monitoring tool to assess the innovation performance of the EU member states is the Innovation Union Scoreboard (IUS), originally called the European Innovation Scoreboard (EIS). Its 2014 edition is based on 25 indicators, of which 10 indicators are *only* relevant for, and a further four *mainly* capture, R&D-based innovations; seven could be relevant for both types of innovations; and a mere four are focusing on non-R&D-based innovations. The current set of the IUS indicators can be seen either as a half-full or a half-empty glass. Compared to the EIS 2004 – as assessed by Jensen et al. (2007) – it is an improvement. Yet, *a much more significant improvement is still needed for a better reflection of the diversity of innovation processes*, which is indispensable for devising effective and sound policies. First, the economic weight of low- and medium-low technology (LMT) sectors is significant in terms of output and employment: these sectors account for around 40% of the EU manufacturing jobs. (EC, 2013b: 5) Second, while the bulk of innovation activities in LMT sectors are not based on intramural R&D efforts, these sectors also improve their performance by innovations. Firms in the LMT sectors are usually engaged in the DUI mode of innovation (that is, relying on learning by doing, using and interacting), but they also draw on advanced S&T results available through the so-called distributed knowledge bases (Robertson and Smith, 2008; Smith, 2002), as well as advanced materials, production equipment, software and various other inputs (e.g. electronics components and sub-systems) supplied by the so-called high-tech (HT) industries. (Bender et al. (eds), 2005; Hirsch-Kreinsen et al. (eds), 2005; Hirsch-Kreinsen and Jacobson (eds), 2008; Hirsch-Kreinsen and Schwinge (eds), 2014; Jensen et al., 2007; Kaloudis et al., 2005; Mendonça, 2009; Sandven et al., 2005; von Tunzelmann and Acha, 2005) Thus, demand by the LMT sectors constitutes major market opportunities for firms in the HT sectors, and also provide strong incentives – and ideas – for their RTDI activities. (Robertson et al., 2009)

Technological innovations can hardly be introduced without organisational and managerial innovations. Moreover, the latter ones – together with marketing innovations – are vital for the success of the former ones. (Pavitt, 1999; Tidd et al., 1997) Thorough empirical analyses have also shown that those companies are the most successful, which consciously combine the STI and DUI modes of innovation. (Jensen et al., 2007)

For the above reasons it would be desirable that *the European Commission* would monitor and assess the member states' RDTI activities by taking into account both the STI and DUI modes of innovation. In other words, indicators should not be biased. On the contrary, *all types of innovations should be considered, irrespective of the form, type and sources of knowledge* exploited (codified vs. tacit; scientific vs. practical; R&D vs. engineering and other production activities, co-operation with various partners, including users, suppliers and the academia), as well as *the sectoral classification of firms* (LMT vs. HT, manufacturing vs.

[39] Further details are discussed in Havas (2015a).

services). That type of monitoring toolkit would be needed to make the EU STI policies sounder, and thus make those more effective and efficient. Moreover, the approach and practice followed by the EC also influences the member states, especially those at the lower level of economic development, and thus including the EU10 countries. Replies given by policy-makers to a recent survey, commissioned by the European Research and Innovation Area Committee (ERAC) indicate that the dominant way of thinking is still based on the science-push model of innovation in most EU member states. (Edquist, 2014a, 2014b)

Given the diversity among innovation systems (in this case: among national innovation systems), one should be very careful when trying to draw policy lessons from the 'rank' of a country as 'measured' by a composite indicator. By its very nature, a scoreboard can only be constructed by using the same set of indicators across all countries, and by applying an identical method to calculate the composite index. Yet, analysts and policy-makers need to realise that poor performance signalled by a composite indicator, and leading to a low ranking on a certain scoreboard, does not automatically identify the area(s) necessitating the most urgent policy actions. For example, when indicators measuring performance in 'high-tech' have a decisive weight in a scoreboard, for a country at a lower level of economic development it is not necessarily an appropriate way of spending public money to try to achieve a higher ranking on that particular scoreboard. It might be more relevant to focus scarce public resources on improving the conditions for knowledge dissemination and exploitation, rather than spending money on creating scientific knowledge in direct competition with advanced, much more affluent countries in those S&T fields where the costs of research are inhibitive. This is a gross oversimplification, of course, that is, far from any policy recommendation at the required level of detail. It is only meant to reiterate that it is a demanding task to devise policies based on the innovation systems approach.[40]

The EU10 countries, therefore, need to avoid the trap of paying too much *attention to simplifying ranking exercises.* Instead, it is of utmost importance to conduct detailed, thorough comparative analyses, identifying the reasons for a disappointing performance, as well as the sources of balanced, sustainable socio-economic development.

New indicators that *better reflect the evolutionary processes of learning and innovation* would also be needed to support policy-making. Developing, piloting and then widely collecting these new indicators would be a major, demanding and time-consuming project, necessitating extensive international co-operation. As it is the best interest of *the EU10 countries*, they *might take the lead in such an initiative*.

8.3 Diversity in innovation performance

Innovation performance of the EU10 countries has been portrayed by using several measures, most of which point to diversity. The share of innovative enterprises in Estonia has been consistently above the EU27 aggregate figure since 1998-2000 (47-49% in 2002-2010 vs. 39-40%), the Czech figures remained slightly below that mark, and Slovenia has made a significant progress, almost closing the gap. The other 7 EU10 countries seem to play in a different league (with a share of innovative firms standing at 16-23% in most of the years considered).

The EU10 countries have shown *different patterns* with regard to the extent and direction of changes concerning the share of innovative enterprises, too. There is neither a clear increasing nor a decreasing trend in this share, with three exceptions. This ratio was falling both in Hungary (from a fairly low level) and Lithuania (from a higher level), while the Slovene data had shown a nearly monotonous growth until 2008-

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[40] Moreover, as the Hungarian and Irish cases, discussed in Havas (2015b) have shown, a high value of a composite indicator would not necessarily signal good performance: the devil is always in the details.

2010, then a small decrease in 2010-2012. An inverted U shape (growth followed by contraction) can be observed in Bulgaria, Estonia, Poland, Romania, and Slovakia. Following a sharp increase, a sort of oscillation can be observed in the Czech Republic and Latvia, in both cases in a relatively close range.

Considering *improvements in labour productivity*, of which innovation is supposed to be a major factor at a micro level, the EU10 countries have also shown *a great diversity*. Four of them have achieved an improvement by 17-23 percentage points between 2002-2012, another four shown an increase between 5-10 percentage points, while two recorded the smallest improvements with 5-8 percentage points. Comparing the data on the *share of innovative enterprises* and those on *labour productivity* reveals *a puzzle*, indicating a need for detailed country analyses. For example, Latvia, Lithuania and Romania are the top 3 performers in enhancing labour productivity, in spite of their low shares of innovative enterprises (both in absolute terms and relative to the other EU10 countries); and in the case of Lithuania not even from a particularly low level. At the other extreme, the Czech Republic has recorded the smallest improvement in labour productivity with a share of innovative enterprises close to the EU27 figure, albeit from a relatively high level of labour productivity.

Taking the share of turnover from innovation in total sales, there are fairly big differences among the EU10 countries, ranging from 3-6% in Latvia to 16-23% in Slovakia. It should be stressed, however, that countries at a rather different level of techno-economic performance are next to each other along this measure, e.g. Latvia, the UK, Lithuania, Bulgaria, Poland, and Sweden in the lower end, while Slovakia, Germany, and Finland in the upper end of this spectrum. Hence, probably one should not overestimate the significance of these data: they should be taken as eye-opening questions to improve the Community Innovation Survey.

Using the Summary Innovation Index (SII), none of the EU10 countries is among the top 10 innovation performers. The best performers among the EU10 countries are Slovenia (No. 11), Estonia (No. 12), and the Czech Republic (No. 14). The remaining 7 EU10 countries take the bottom 7 positions.

The *dynamics of innovation performance of the EU10 countries*, as measured by the IIS, have not been identical, either. Eight of the EU10 countries have shown an almost monotonous improvement: the Czech Republic, Estonia, Hungary, Latvia, Lithuania, Romania, Slovakia, and Slovenia. In contrast, an inverted U-shape – that is, an initial improvement followed by falling behind compared to a country's own performance – can be observed in Bulgaria and Romania.

The *Global Innovation Index* takes into 81 indicators that are meant to measure conditions and performance along 7 pillars: Institutions, Human capital and research, Infrastructure, Market sophistication, Business sophistication, Knowledge and technology outputs, and Creative outputs. Considering the rankings of the EU10 countries and the four 'classic' cohesion countries, and pulling them into a group (that is, calculating their relative position inside this group, using their GII ranking), *four EU10 countries have achieved a slight improvement*, or kept her position: Estonia, the Czech Republic, and Romania have gained 1 place by 2014 compared to 2007, while Lithuania was ranked at the same place in both years. *Three countries have been doing even better*: Slovenia has gained 4 positions, while both Latvia and Bulgaria improved her ranking by 3 places. The remaining *three countries have worsened their ranking*: Hungary has lost 1 position, while Poland and Slovakia 2 and 5 places, respectively.

Business-academia collaborations have also been analysed in this paper as an important factor in determining innovation performance. Various measures have been considered: the weight of business resources in funding R&D activities conducted at universities and other publicly financed R&D organisations; information sources for innovation (frequency of use and importance); as well as innovation co-operation methods (occurrence of co-operation with various types of partners and usefulness of a given co-operation method). *A great diversity can be observed among the EU10 countries along these dimensions, too*.

8.4 STI policies pursued in the EU10 countries

Given the diversity of the EU10 countries highlighted from various angles in this paper, as well as in the above summary, one would assume that fairly different needs can be identified in the EU10 countries, necessitating differentiated, 'tailored' policy responses. Yet, these countries follow the same STI policy rationale to a large extent, namely the market failure argument, which itself can be seen as a unifying force. It is the 'translation' of the science-push model of innovation into the theoretical framework of mainstream economics. In this logic the main source of information for innovation is R&D – contrary to the wide variety of information sources revealed by the respondents of the Community Innovation Survey, consistently throughout its various rounds (section 5.2), and the huge significance attributed to information obtained from other firms (other enterprises in the case of an enterprise group; suppliers; clients and customers; competitors and other firms in the same sector), as well as the usefulness accredited to collaboration with these business partners (section 5.3). R&D, in turn, should be driven by the universal rules of science, in pursuing scientific excellence that is supposed to leading to impressive ('killer') high-tech products and solutions. The uniformity of this STI policy rationale is thus further strengthened by this self-reinforcing mechanism: the rules of science are universal, and STI policies should be driven by the principal aim of promoting R&D activities.

Evolutionary economics of innovation, in contrast, rests on the recognition of the diversity of knowledge (in terms of its sources, types and forms) required for successful innovation. As these different types and forms of knowledge are rarely possessed by a single actor, knowledge flows and co-operation among actors in an innovation system are crucial (again, see section 5). Hence, STI policies need to focus on addressing all sorts of systemic failures (problems) that hinder the generation, diffusion and utilisation of any type and form of knowledge required for successful innovation.

Yet, the cluster analysis of policies summarised in section 7 reveals that innovation policies pursued in the EU10 countries reflect much more 'the best practice' (as perceived by many advisers and policy-makers), not their specific technological positions and constraints. More specifically, the 'science – collaboration' policy mix model can be found in all four groups defined by the IUS (using the SII). It is the most common model followed by countries being at very different technological levels. That reflects an unexpectedly high homogeneity of policy mixes despite the relatively big differences between countries concerning the level of their technological and economic development and the differences with respect to the role of knowledge generation vs. knowledge absorption in their (potential) economic development. The exclusive focus on policy transfer and the diffusion of 'best practice' de facto precludes a critical understanding of the factors that influence a country's technology upgrading.

Replacing the science-push model with the systemic view of innovation as the underlying logic of the EU10 STI policies – in other words, shifting from the market failure argument to the systemic failure STI policy rationale – could bring significant benefits. First, that would allow embracing a broader approach to innovation, and thus reducing opportunity costs. STI policies driven by the science-push model disregard non-R&D types of knowledge, which are of huge significance for innovation processes in the LMT branches of manufacturing and services. Given the substantial economic weight of these sectors in producing output and creating employment, this policy ignorance is likely to lead to massive opportunity costs, e.g. in the form of lost improvements in productivity, 'unborn' new products and services, and thus 'unopened' new markets and 'undelivered' new jobs.

Second, scoreboards and league tables compiled following the science-push logic, and published by supranational organisations, can easily lead to 'lock-in' situations. National policy-makers – and politicians, in particular – are likely to pay much more attention to their country's position on a scoreboard than to nuanced assessments or policy recommendations in lengthy documents, and hence this inapt logic is 'diffused' and strengthened at the national level, too, preventing policy learning and devising appropriate policies. Despite the likely original intention, that is, to broaden the horizon of decision-makers by offering internationally comparable data, these scoreboards and league tables strengthen a narrow-minded, simplifying approach. In other words, the shift in policy thinking proposed here would allow *taking into account the specific strengths and weaknesses of a given country, a deeper understanding of its context, and thus devising more appropriate STI policies* (as opposed to the currently observed 'uniformity').

No doubt, STI policy implications derived from evolutionary theorising are demanding both in terms of the analytical efforts needed to underpin policies and policy design capabilities. The market failure rationale is an abstract concept; its policy implications are supposed to apply to any market in any country, and at any time – but exactly for being abstract, it cannot provide appropriate guidance for policy design. The systemic failures argument, in contrast, cannot offer 'one-size-fits-all' recipes. Instead, it stresses that it is an empirical task to identify what type of failure(s) is (are) blocking innovation processes in what part of a given innovation system in order to guide the design of appropriate policies. Besides thorough analyses, it is likely to demand extensive dialogues with stakeholders, too. That would require apparently extra resources (which are not incurred in a 'traditional', widely used way of decision-making): time, money and attention of policy-makers. It thus can – and indeed, should be – seen as an investment into improving policy processes, and indirectly the policy governance sub-system, too.

Identifying systemic 'problems' – by their nature specific to a particular innovation system – is not a trivial task and the possibility of summarising widely applicable, easy-to-digest and thus appealing policy 'prescriptions' in one or two paragraphs is excluded on theoretical grounds.

The systemic approach implies, too, that several policies affect innovation processes and performance – and perhaps even more strongly than STI policies. Hence, the task of designing effective and efficient policies to promote innovation is even more complex as policy goals and tools need to be orchestrated across several policy domains, including macroeconomic, education, investment promotion, regional development, competition, and labour market policies, as well as health, environment and energy policies aimed at tackling various types of the so-called grand challenges. That is *a major challenge for the EU10 countries, given their current level of policy-making capacities* and *the lack of appropriate policy co-ordination structures and mechanisms.*

Finally, some basic principles for policy-making can also be distilled from the systemic view of innovation. Given the characteristics of innovation processes, public policies should be aimed at *promoting learning in its widest possible sense*: competence building at individual, organisational and inter-organisational levels; in all economic sectors, in all possible ways, considering all types of knowledge, emanating from various sources, and taking different forms. Further, as it already occurs in some countries*, innovation (and other) policies should promote the introduction of new processes and methods in public services and administration, too*.

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Appendix: Further statistics

Table A1: The share of EU10 countries' GDP in the EU28 total (percentage of EU28 total, based on million PPS, current prices)

	1996	2000	2004	2006	2008	2010	2012	2013
Bulgaria	0.5	0.5	0.5	0.6	0.7	0.6	0.6	0.6
Czech Republic	1.7	1.5	1.6	1.7	1.7	1.7	1.7	1.7
Estonia	n.a.	0.1	0.2	0.2	0.2	0.2	0.2	0.2
Latvia	0.2	0.2	0.2	0.2	0.3	0.2	0.2	0.3
Lithuania	n.a.	n.a.	0.3	0.4	0.4	0.4	0.4	0.4
Hungary	1.1	1.1	1.3	1.3	1.3	1.3	1.3	1.3
Poland	3.5	3.7	3.8	3.9	4.1	4.7	5.0	5.1
Romania	1.5	1.2	1.5	1.6	2.0	2.0	2.1	2.1
Slovenia	0.3	0.3	0.3	0.3	0.4	0.3	0.3	0.3
Slovakia	0.5	0.5	0.6	0.7	0.8	0.8	0.8	0.8
EU10	9.3	9.1	10.3	10.9	11.9	12.2	12.6	12.8

Source: Eurostat

Table A2: The share of EU10 countries' population in the EU28 total (%)

	1996	2000	2004	2006	2008	2010	2012	2013
Bulgaria	1.7	1.7	1.6	1.5	1.5	1.5	1.4	1.4
Czech Republic	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1
Estonia	n.a.	0.3	0.3	0.3	0.3	0.3	0.3	0.3
Latvia	0.5	0.5	0.5	0.4	0.4	0.4	0.4	0.4
Lithuania	0.7	0.7	0.7	0.7	0.6	0.6	0.6	0.6
Hungary	2.1	2.1	2.0	2.0	2.0	2.0	2.0	1.9
Poland	7.9	7.8	7.7	7.7	7.6	7.6	7.6	7.6
Romania	4.7	4.6	4.3	4.3	4.1	4.0	4.0	3.9
Slovenia	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
Slovakia	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1
EU10	21.3	21.3	20.7	20.4	20.1	20.0	19.7	19.6

Source: Eurostat

Table A3: FTE researchers in the EU10 countries and the EU27 total by sector of performance, various years

		1996	2000	2006	2012
EU27	All sectors	991,666	1,094,313	1,416,722	1,643,672
	Business enterprise sector	447,034	503,377	653,269	763,993
	Government sector	167,991	166,791	183,125	200,045
	Higher education sector	365,055	412,473	563,336	660,040
	Private non-profit sector	n.a.	11,672	16,993	19,594
EU10	All sectors	145,769	141,935	165,805	192,493
	Business enterprise sector	43,986	38,441	42,261	59,752
	Government sector	45,944	39,637	43,257	43,472
	Higher education sector	58,483	63,537	79,761	88,534
	Private non-profit sector	n.a.	320	525	734

		1996	2000	2006	2012
Bulgaria	All sectors	14,751	9,479	10,336	11,295
	Business enterprise sector	1,752	1,139	1,304	2,090
	Government sector	8,007	6,417	6,148	5,339
	Higher education sector	4,847	1,886	2,756	3,754
	Private non-profit sector	145	37	128	112
Czech Republic	All sectors	12,963	13,852	26,267	33,169
	Business enterprise sector	4,863	5,533	11,053	15,444
	Government sector	4,574	4,424	6,800	6,066
	Higher education sector	3,505	3,768	8,352	11,450
	Private non-profit sector	21	127	61	208
Estonia	All sectors	n.a.	2,666	3,513	4,570
	Business enterprise sector	n.a.	274	876	1,409
	Government sector	1,339	559	513	546
	Higher education sector	1,669	1,806	2,042	2,534
	Private non-profit sector	20	27	82	81
Latvia	All sectors	2,839	3,814	3,935	3,904
	Business enterprise sector	318	995	688	594
	Government sector	1,302	662	598	703
	Higher education sector	1,218	2,156	2,648	2,607
	Private non-profit sector	1	1	1	:
Lithuania	All sectors	7,532	7,777	7,980	8,023
	Business enterprise sector	89	288	877	1,317
	Government sector	2,915	2,557	1,651	1,372
	Higher education sector	4,479	4,932	5,452	5,334
	Private non-profit sector	49	n.a.	n.a.	n.a.
Hungary	All sectors	10,408	14,406	17,547	23,837
	Business enterprise sector	2,626	3,901	6,248	13,231
	Government sector	3,925	4,653	5,226	4,674
	Higher education sector	3,857	5,852	6,073	5,932
	Private non-profit sector	n.a.	n.a.	n.a.	n.a.
Poland	All sectors	52,474	55,174	59,573	67,001
	Business enterprise sector	10,365	9,821	9,344	15,088
	Government sector	10,954	11,100	12,438	13,583
	Higher education sector	31,133	34,246	37,653	38,152
	Private non-profit sector	22	7	137	178
Romania	All sectors	30,303	20,476	19,021	16,330
	Business enterprise sector	20,343	12,690	7,708	3,270
	Government sector	7,496	5,244	5,585	6,372
	Higher education sector	2,464	2,542	5,652	6,591
	Private non-profit sector	n.a.	n.a.	76	97
Slovenia	All sectors	4,489	4,336	5,857	9,093
	Business enterprise sector	1,371	1,380	2,262	4,827
	Government sector	1,581	1,495	1,804	1,850
	Higher education sector	1,411	1,340	1,763	2,398
	Private non-profit sector	126	121	28	18
Slovakia	All sectors	10,010	9,955	11,776	15,271
	Business enterprise sector	2,259	2,420	1,901	2,482
	Government sector	3,851	2,526	2,494	2,967
	Higher education sector	3,900	5,009	7,370	9,782
	Private non-profit sector	n.a.	n.a.	12	40

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

Note: 1996 is the first year when EU10 countries' data are almost fully available in the Eurostat database. 1996 data for the EU27 total has been calculated by adding the Bulgarian and Romanian figures to the 1996 data for EU25 (downloaded on 8 May 2007).

Table A4: R&D expenditures in the EU10 countries and the EU27 total by sector of performance, various years (million €, current prices)

		1996	2000	2006	2012
EU27	All sectors	129,457.7	171,155.7	216,266.4	269,548.29
	Business enterprise sector	81,023.4	111,291.7	137,301.5	171,092.26
	Government sector	20,776.9	23,396.2	28,444.8	33,014.05
	Higher education sector	26,763.7	35,108.9	48,246.4	63,087.10
	Private non-profit sector	893.7	1,358.9	2,273.7	2,354.88
EU10	All sectors	2,164.8	3,153.7	5,659.2	10,801.5
	Business enterprise sector	1,080.8	1,476.6	2,631.1	5,326.0
	Government sector	680.5	916.7	1,608.2	2,408.5
	Higher education sector	410.0	728.1	1,376.9	3,008.5
	Private non-profit sector	4.1	9.7	24.9	39.4
Bulgaria	All sectors	41.1	71.3	121.2	253.7
	Business enterprise sector	24.2	15.2	30.9	153.5
	Government sector	13.5	49.0	77.7	76.2
	Higher education sector	3.2	7.0	11.6	20.4
	Private non-profit sector	0.2	0.1	1.0	3.6
Czech Republic	All sectors	472.0	744.0	1,526.6	2,877.3
	Business enterprise sector	282.9	446.1	911.6	1,542.4
	Government sector	146.9	188.4	328.4	529.7
	Higher education sector	41.8	105.7	279.4	790.4
	Private non-profit sector	0.4	3.8	7.2	14.7
Estonia	All sectors	n.a.	37.0	151.0	380.7
	Business enterprise sector	n.a.	8.3	67.1	219.0
	Government sector	12.6	8.6	19.8	35.4
	Higher education sector	6.8	19.4	61.3	122.3
	Private non-profit sector	0.1	0.7	2.7	4.0
Latvia	All sectors	18.7	37.5	112.3	146.5
	Business enterprise sector	5.1	15.1	56.6	33.1
	Government sector	8.2	8.3	16.9	39.7
	Higher education sector	5.4	14.1	38.8	73.7
	Private non-profit sector	0.0	0.0	0.0	n.a.
Lithuania	All sectors	32.5	73.0	190.5	298.4
	Business enterprise sector	1.2	15.7	53.2	80.3
	Government sector	20.8	30.6	43.5	58.4
	Higher education sector	10.2	26.7	93.8	159.6
	Private non-profit sector	0.3	n.a.	n.a.	n.a.
Hungary	All sectors	231.7	405.3	900.5	1,257.3
	Business enterprise sector	100.0	179.6	434.7	825.1
	Government sector	65.7	105.7	228.5	181.6
	Higher education sector	57.4	97.3	219.3	231.5
	Private non-profit sector	n.a.	n.a.	n.a.	n.a.
Poland	All sectors	806.9	1,196.6	1,512.6	3,429.9
	Business enterprise sector	330.2	431.8	477.0	1,276.3
	Government sector	251.1	385.9	560.1	958.9
	Higher education sector	224.6	377.3	468.9	1,181.0
	Private non-profit sector	1.0	1.6	6.5	13.5
Romania	All sectors	195.9	148.7	444.1	644.2
	Business enterprise sector	144.0	103.2	215.3	251.0
	Government sector	45.4	28.0	143.6	263.6
	Higher education sector	6.5	17.5	78.7	127.1
	Private non-profit sector	n.a.	n.a.	6.4	2.6
Slovenia	All sectors	214.3	297.3	483.8	928.3
	Business enterprise sector	108.6	167.5	291.4	703.1

		1996	2000	2006	2012
	Government sector	57.1	77.0	118.6	121.5
	Higher education sector	46.3	49.4	73.0	103.3
	Private non-profit sector	2.4	3.5	0.8	0.4
Slovakia	All sectors	151.7	142.9	216.6	585.2
	Business enterprise sector	84.7	94.0	93.3	242.0
	Government sector	59.3	35.3	71.0	143.5
	Higher education sector	7.8	13.6	52.2	199.1
	Private non-profit sector	0.0	0.0	0.2	0.6

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

Notes: 1996 is the first year when EU10 countries' data are almost fully available in the Eurostat database. 2012 data are for the EU28 (instead of EU27).

Table A5: The share of innovative enterprises: Bulgaria (%)

	1998-2000	2002-2004	2004-2006	2006-2008	2008-2010	2010-2012
Small enterprises (10–49 employees)	9.7	13.5	17.0	20.3	13.7	12.9
Medium-sized enterprises (50–249)	16.1	22.8	26.4	32.0	28.8	27.4
Large enterprises (250 –)	20.6	33.3	52.7	59.2	47.8	45.6
Total	11.4	16.1	20.2	23.9	17.7	16.9

Source: Eurostat

Table A6: The share of innovative enterprises: Czech Republic (%)

	1998-2000	2002-2004	2004-2006	2006-2008	2008-2010	2010-2012
Small enterprises (10–49 employees)	24.7	32.3	28.9	34.5	29.6	29.8
Medium-sized enterprises (50–249)	42.2	50.2	48.6	48.9	46.5	49.3
Large enterprises (250 –)	65.7	69.8	70.4	70.5	66.2	71.7
Total	30.3	38.3	35.0	39.3	34.8	35.6

Source: Eurostat

Table A7: The share of innovative enterprises: Estonia (%)

	1998-2000	2002-2004	2004-2006	2006-2008	2008-2010	2010-2012
Small enterprises (10–49 employees)	31.1	45.3	43.0	41.6	40.2	33.1
Medium-sized enterprises (50–249)	48.3	57.9	64.4	67.4	67.7	55.8
Large enterprises (250 –)	75.4	79.8	85.2	88.8	92.5	72.8
Total	35.7	48.7	48.2	47.9	46.7	38.4

Source: Eurostat

Table A8: The share of innovative enterprises: Hungary (%)

	1998-2000	2002-2004	2004-2006	2006-2008	2008-2010	2010-2012
Small enterprises (10–49 employees)	20.9	16.9	15.6	16.3	13.3	12.2
Medium-sized enterprises (50–249)	28.0	30.5	31.6	31.3	32.7	26.6
Large enterprises (250 –)	44.4	52.4	55.5	59.2	60.0	53.9
Total	23.3	20.8	20.1	20.8	18.4	16.4

Source: Eurostat

Table A9: The share of innovative enterprises: Latvia (%)

	1998-2000	2002-2004	2004-2006	2006-2008	2008-2010	2010-2012
Small enterprises (10–49 employees)	14.5	14.1	13.1	16.9	13.1	16.2
Medium-sized enterprises (50–249)	32.6	27.2	23.7	30.0	27.7	30.2
Large enterprises (250 –)	58.1	53.5	48.4	63.0	49.0	47.9
Total	19.3	17.5	16.2	20.1	16.7	19.5

Source: Eurostat

Table A10: The share of innovative enterprises: Lithuania (%)

	1998-2000	2002-2004	2004-2006	2006-2008	2008-2010	2010-2012
Small enterprises (10–49 employees)	21.2	22.4	18.3	19.3	19.0	14.5
Medium-sized enterprises (50–249)	40.1	42.0	39.1	34.0	28.9	30.9
Large enterprises (250 –)	63.5	64.3	58.8	62.8	58.7	56.7
Total	28.0	28.5	22.3	23.9	22.6	18.9

Source: Eurostat

Table A11: The share of innovative enterprises: Poland (%)

	1998-2000	2002-2004	2004-2006	2006-2008	2008-2010	2010-2012
Small enterprises (10–49 employees)	12.9	18.4	15.5	14.3	10.4	10.7
Medium-sized enterprises (50–249)	24.6	39.4	37.7	31.6	28.6	28.4
Large enterprises (250 –)	53.5	64.4	64.1	58.7	57.6	55.9
Total	17.3	24.8	23.0	19.8	16.2	16.1

Source: Eurostat

Table A12: The share of innovative enterprises: Romania (%)

	1998-2000	2002-2004	2004-2006	2006-2008	2008-2010	2010-2012
Small enterprises (10–49 employees)	13.2	15.7	17.2	16.6	11.7	4.6
Medium-sized enterprises (50–249)	21.3	24.3	26.6	26.0	19.4	4.6
Large enterprises (250 –)	40.9	41.8	41.6	44.1	39.6	4.6
Total	17.0	19.5	20.7	19.7	14.3	6.3

Source: Eurostat

Table A13: The share of innovative enterprises: Slovakia (%)

	1998-2000	2002-2004	2004-2006	2006-2008	2008-2010	2010-2012
Small enterprises (10–49 employees)	15.1	16.0	19.1	16.7	22.7	15.9
Medium-sized enterprises (50–249)	24.4	34.3	33.7	35.5	34.1	25.4
Large enterprises (250 –)	46.8	57.8	56.2	56.5	56.7	43.4
Total	19.5	22.9	24.9	21.7	28.1	19.7

Source: Eurostat

Table A14: The share of innovative enterprises: Slovenia (%)

	1998-2000	2002-2004	2004-2006	2006-2008	2008-2010	2010-2012
Small enterprises (10–49 employees)	12.7	19.1	27.7	27.6	27.4	26.0
Medium-sized enterprises (50–249)	28.3	40.9	51.3	49.3	52.5	49.5
Large enterprises (250 –)	55.4	69.9	76.9	81.2	82.2	79.9
Total	21.1	26.9	35.1	34.4	34.7	32.7

Source: Eurostat