DOI: 10.1007/s10272-015-0521-7

The Impact of Horizon 2020 on Innovation in Europe

The EU's stagnation on many innovation indicators led to a number of efforts to spur a turnaround. One of most visible projects has been the Horizon 2020 strategy, which devotes unprecedented levels of funding to the promotion of R&D and innovation. But does this strategy address the right issues to promote innovation? Is Horizon 2020 right to ignore geographical considerations when allocating funding? What policy instruments does Horizon 2020 recommend, and has it led to novel strategies being employed, beyond the increase in R&D funding? What steps are individual countries taking? Most importantly, what impact is Horizon 2020 actually having on innovation in the EU?

Reinhilde Veugelers* and Michele Cincera

How to Turn on the Innovation Growth Machine in Europe

Europe maintains lofty ambitions for building its future growth and prosperity and safeguarding its social model through innovation. The European Union carved its ambition to become the most competitive knowledge-based economy in the world into its 2002 Lisbon Strategy. An ambitious target of devoting three per cent of GDP to R&D by 2010 was set. And in its subsequent Europe 2020 strategy and Innovation Union Flagship, it set out a roadmap for sustainable and inclusive growth that needs to be *smart*.

Despite this policy of attention to innovation-based growth and R&D targeting, Europe's performance on innovation remains weak to date. According to the Innovation Union Scoreboard (IUS) indicator, developed by the European Commission in support of its Innovation Union Strategy,[1] Europe is not doing well.[2] Europe's gap relative to the US holds across almost all individual indicators that go into the IUS score. This is a reflection of the *systemic* nature of Europe's failing innovation capacity. Europe's overall (public and private) R&D-to-GDP ratio currently stands below two per cent, significantly lower than the ratios in the US, Japan, South Korea and Singapore. Furthermore, there are relatively few signs of progress. China is fast catching up and already on par with the EU.

Why is it so hard to improve Europe's innovative performance? Does Europe have the capacity for knowledge-based growth? This contribution takes a close look at the evidence on Europe's innovation performance. We look at heterogeneity across European countries: Do some countries or parts of Europe do better than others? Is there a convergence over time among European countries in innovation capacity along a process of integration? The analysis finds that Europe maintains an innovation system, with a few well performing countries, in which a slow process of convergence is taking place. Within the innovation ecosystem, it is particularly the business sector that generates an innovation deficit, and this business sector deficit is highly persistent over time.

Why does Europe's business sector, despite having some top performers, have a persistently lower innovative capacity on average when compared to the US? We investigate the age and sector composition of Europe's

* Reinhilde Veugelers acknowledges financial support from KULeuven (GOA/12/003) and FWO Flanders (G.0825.12), as well as the comments received from the participants of the EUROFORUM Conference, June 2013, Leuven, especially Michel Praet and Bruno van Pottelsberghe.

1 IUS is a composite indicator capturing eight dimensions of innovation: Human Resources, Research Systems, Finance, Firm Investment, Linkages, IPR, Innovations and Economic Effects. For the international benchmarking of Europe, it uses information from 12 indicators to assess these eight dimensions.

2 European Commission: Innovation Union Competitiveness report, 2011.

business innovation structure and identify the lack of young innovative companies ("yollies") in innovation-based growth sectors as the major source of Europe's persistent lagging business innovation deficit relative to the US. Europe simply has too few yollies in the right sectors, which can form the nucleus for a capacity to shift economies towards new opportunities for growth.

The obvious next issue we examine is why Europe is less capable of nurturing new strong innovative firms in new sectors. What are the major impediments facing innovative firms in new sectors in Europe? We focus on an important impediment that hampers young firms with highly innovative growth projects, namely access to early-stage risk finance.

The paper concludes with some policy implications. What can Europe do to make its ambitions for knowledge-based growth more realistic? A policy agenda that can tackle the systemic deficit is not easy to establish and requires a long-term commitment to support innovation.

Europe's persistent differences in innovation performance

Although integration has resulted in some level of convergence in innovation, the pace of convergence is slow. There still remain substantial country differences, not only in terms of stock of knowledge but also in the varying capacities to leverage knowledge into growth. To assess convergence, we look at the σ-coefficient, i.e. the coefficient of variation (√VAR/MEAN). σ-convergence occurs when the dispersion across a group of economies decreases over time.

In the 2011 IUS exercise, the best performing ("frontier") countries were Sweden, Denmark, Germany and Finland. The weakest group of countries includes most transition economies, including Latvia, Bulgaria, Lithuania and Romania.

As Table 1 shows, the coefficient of variation on the IUS score is high, illustrating the high level of heterogeneity on innovation capacity in Europe. Although it has slightly decreased in the period 2006-2010, reflecting a slow process of σ-convergence, dispersion remains substantial. This dispersion holds between frontier and "catching-up" countries, as the difference in average scores of both groups demonstrates (see Panel B). Over the time period considered, a slow catching-up has taken place between the catching-up and the frontier countries in Europe, as the gap scores indicate, but the gap remains considerable. Within both groups, however, there is also substantial heterogeneity, particularly in the catching-up countries, as the coefficient of variation indicates (see Panel C). This dispersion has only slightly decreased in the period considered. Furthermore, in the group of frontier countries, the gap between the top five and the rest is highly stable over time.

As the business sector is responsible for most of Europe's R&D intensity gap relative to the US, and as this shows a persistent time pattern, we further zero in on the heterogeneity and convergence across European countries in the business component of R&D expenditures.

The heterogeneity in business R&D performance across European countries is substantial, as the coefficient of variation shows. And although the coefficient of variation has decreased over time, demonstrating σ-convergence, the pace of convergence is slow.

Overall, the data show the extreme immobility of business R&D performance in Europe. At the same time,

Reinhilde Veugelers, University of Leuven, Belgium; and Bruegel, Brussels, Belgium.

Michele Cincera, Université Libre de Bruxelles, Belgium.

Rainer Frietsch, Fraunhofer Institute for Systems and Innovation Research, Karlsruhe, Germany.

Torben Schubert, Fraunhofer Institute for Systems and Innovation Research, Karlsruhe, Germany; and Lund University, Sweden.

Christian Rammer, Centre for European Economic Research (ZEW), Mannheim, Germany.

Anita Pelle, University of Szeged, Hungary.

Andrea Renda, Centre for European Policy Studies, Brussels, Belgium.

Jos Leijten, Joint Institute for Innovation Policy, Brussels, Belgium.

Carlos Montalvo, Netherlands Organisation for Applied Scientific Research TNO, Delft, Netherlands.

Table 1

Heterogeneity and convergence in Europe on innovation performance

IUS	2006	2010
Panel A: Within Europe[1]		
Average Europe	0.41	0.45
Coefficient of variation	0.43	0.40
Top countries	SE, CH, DK, DE, FI (0.758-0.638)	CH, SE, DK, FI, DE (0.831-0.696)
Bottom countries	BG, LV, TR, RO (0.159-0.219)	LV, TK, BG, LT, RO (0.201-0.237)
Panel B: Frontier versus catching-up countries[2]		
Average frontier countries	0.59	0.62
Coefficient of variation	0.20	0.19
Average catching-up	0.30	0.34
Coefficient of variation	0.36	0.33
Gap catching-up/frontier (=100)	0.51	0.55
Panel C: Within frontier; within catching-up[3]		
Average frontier countries	0.59	0.62
Top 5	0.70	0.74
Non-top 5	0.52	0.55
Average catching-up	0.30	0.34
Former cohesion countries	0.39	0.44
EU13	0.29	0.33

[1] The range of IUS scores, in brackets, for the group of countries considered includes, in addition to the EU27, Switzerland and accession countries. Due to their small size, we do not report on LU, MT, CY, MK and IC. [2] The catching-up countries include the EU13, the four former cohesion countries, the other transition countries and Turkey. There are 13 frontier countries (AT, BE, DK, FI, FR, DE, IT, LU, NL, NO, SE, CH, UK). [3] The Top 5 countries are CH, SE, DE, FI and DK; former cohesion countries are ES, PT, IE and EL.

Source: Own calculations based on Innovation Union Scoreboard, 2011.

there is substantial heterogeneity within Europe, which goes beyond the divide between old and new member states and also involves countries like Greece at the bottom. The process of structural change and convergence/catching up within Europe is very slow, as indicated by the very stable rankings of European countries over time on business R&D performance.

Age and sectoral composition effects on Europe's business R&D deficit

The continued business R&D deficit is central in Europe's innovation deficit. It is a symptom of its low capacity for both structural change and a shift towards new growth areas. What explains this business R&D deficit? Why does Europe's business sector have less innovative capacity on average when compared to the

Table 2

Business R&D expenditures in Europe

Business R&D as % of GDP

	2004	2008
Average EU27	1.16	1.21
Coefficient of variation	0.98	0.86
Top countries	SE, FI, CH (2.63-2.14)	FI, SE, CH, DK (2.76-2.01)
Bottom countries	BG, TK, PL, LT, EL, LV, RO (0.12-0.21)	BG, LV, EL, RO (0.10-0.17)

Source: Own calculations based on Innovation Union Scorecard, 2010.

US, despite its top performers? And why is this deficit so persistent? In line with O'Sullivan, Aghion et al. and others, this contribution claims that Europe's persistent business innovation gap is correlated with its industrial structure.[3] New firms fail to play a significant role in the innovation dynamics of European industry, especially in the high-tech sectors. This is illustrated by their inability to enter the market, and more importantly, for the most efficient innovative entrants to grow to world leadership. The churning that characterises the creative destruction process in a knowledge-based economy encounters significant obstacles in the EU, suggesting barriers to growth for new innovating firms that ultimately weaken Europe's growth potential. Bartelsman et al. found that post-entry performance differs markedly between Europe and the US,[4] which suggests the importance of barriers to company growth. This inability of new European firms to grow large seems to manifest itself particularly in the high-tech, high-growth sectors, most notably the ICT sector. This correlates with the European economy's lower degree of specialisation in the R&D-intensive, high-growth sectors of the 1990s, again most notably the ICT sectors.[5]

This structural European innovation deficit story, related to company age and the sectoral make-up of the economy, has recently attracted much attention. It has been

3 M. O'Sullivan: The EU's R&D deficit and innovation policy, report of the Expert Group on Knowledge for Growth, European Commission, Brussels 2008; P. Aghion, E. Bartelsman, E. Perotti, S. Scarpetta: Barriers to exit, experimentation and comparative advantage, RICAFE2 WP 056, London School of Economics, 2008.

4 E. Bartelsman, J. Haltiwanger, S. Scarpetta: Microeconomic evidence of creative destruction in industrial and developing countries, Tinbergen Institute Discussion Papers 04-114/3, Tinbergen Institute, 2004.

5 P. Moncada-Paterno-Castello, C. Ciupagea, K. Smith, A. Tubke, M. Tubbs: Does Europe perform too little corporate R&D?, in: Research Policy, Vol. 39, 2009, pp. 523-536.

investigated in more detail in Veugelers and Cincera,[6] in which the JRC-EC-IPTS Industrial R&D Scoreboard figures of global R&D expenditures of leading innovators by age cohort and sector are decomposed.[7] Their analysis confirms that the major source of Europe's lagging business innovation deficit relative to the US is the lack of yollies, i.e. young companies that have grown into world-leading innovators, in new innovation-based growth sectors.

The age composition of Europe's leading innovators

Among the US leading innovators in the Industrial R&D Scoreboard, more than half are "young" (i.e. born after 1975), qualifying them as yollies. US yollies include Microsoft, Cisco, Amgen, Oracle, Google, Sun, Qualcomm, Apple, Genzyme and Ebay. By contrast, in Europe only one out of five leading innovators is "young". Yollies account for 35 per cent of total business R&D in the US, while in Europe this figure is a mere seven per cent!

The R&D intensity of European leading companies, whether old or young, is on average smaller than the world average, particularly in comparison to the US. With the US benchmarked at 100, Europe's overall R&D intensity gap score is 63 per cent. This gap holds both for older companies ("ollies") and yollies. But the difference is more pronounced for yollies. While the R&D intensity gap score for Europe's ollies is 80 per cent, the score for yollies is 43 per cent.

The lower overall R&D intensity of Europe's leading innovators can thus be explained by the combination of the following facts:

- Europe has fewer yollies than the US. This matters because yollies have a higher level of R&D intensity when compared to ollies.
- Europe-based yollies are less R&D-intensive than their US counterparts.
- European ollies are also less R&D-intensive than their US counterparts.

As the difference in RDI between Europe and the US is small for ollies, the most important factor in Europe's overall RDI deficit is related to yollies: not only that Europe has fewer of them, but also that the yollies that Europe has are less R&D-intensive than their US counterparts.

Table 3
EU and US sector specialisation of R&D activities in innovation-based growth sectors

	EU	US
Aerospace & defence	1.50	1.13
Biotechnology	0.32	2.20
Computer hardware & computer services	0.08	1.39
Health care equipment & services	0.70	1.86
Internet	0	2.54
Pharmaceuticals	1.27	1.16
Semiconductors	0.50	1.72
Software	0.51	2.05
Telecommunications equipment	1.38	1.09
All IBG sectors	0.89	1.43

Note: Revealed technological advantages (RTAs) are calculated as the share of the region in total sectoral R&D relative to the share of the region in overall R&D. An RTA value higher than 1 reflects that the region is technologically specialised in this sector.

Source: Based on R. Veugelers, M. Cincera: Young Leading Innovators and EU's R&D intensity gap, Bruegel Policy Contribution 2010/09, Bruegel, Brussels 2010.

The sectoral composition of Europe's leading innovators

To analyse the sectoral composition problem for explaining Europe's lagging business R&D deficit, we look at the sectors in which Europe specialises its R&D activities. We are particularly interested in Europe's position in the sectors that offer the largest scope for knowledge-based growth. To this end, we identify sectors that have (i) an above-average level of R&D intensity, (ii) an above-average R&D growth rate and/or (iii) an above-average share of young companies among their leading innovators. This set of sectors includes aerospace, biotechnology, computer hardware & services, health care equipment & services, internet, pharmaceuticals, semiconductors, software, and telecom equipment. These are all sectors in the ICT and the health realms. We label these sectors "innovation-based growth sectors" (IBG sectors).

Table 3 shows Europe's R&D positions in the IBG sectors in which it specialises. When looking at the individual IBG sectors, Europe only has revealed technological advantages (RTAs) in aerospace, pharmaceuticals and telecom equipment, of which only the latter is a "young"

6 R. Veugelers, M. Cincera: Europe's Missing Yollies, Bruegel Policy Brief 2010/06, Bruegel, Brussels 2010; R. Veugelers, M. Cincera: Young Leading Innovators and EU's R&D intensity gap, Bruegel Policy Contribution 2010/09, Bruegel, Brussels 2010.

7 European Commission: The 2008 EU Industrial R&D Investment Scoreboard, 2008.

sector. The US, by contrast, specialises in all IBG sectors.[8]

Europe's sectoral composition, i.e. its failure to specialise in the sectors with the biggest opportunities for knowledge-based growth, not only explains Europe's overall lagging R&D performance. It can also explain why Europe's young leading innovators are underperforming on R&D. It is not because European yollies are less R&D-intensive when compared to their US counterparts in the same sectors (the so-called intrinsic effect). Rather, it is because European yollies operate primarily in less R&D-intensive sectors (the so-called structural effect).

Table 4 shows that Europe has significantly fewer of its yollies in the sectors with the greatest opportunities for innovation-based growth. In the Internet sector, Europe does not have a single company that has achieved "Leading Innovator" status. In biotechnology, as well, Europe has fewer yollies when compared to the US. Both of these sectors thus serve to illustrate Europe's inability to raise young innovators to leading status in sectors with high innovation-based growth potential (structural effect). But the young innovators it has in these sectors are as R&D-intensive as their US counterparts, if not even more so. This holds particularly in the ICT sectors. Table 4 thus confirms that the lower R&D intensity of Europe's Young Leading Innovators, when compared to their US counterparts, is due to a structural, sectoral composition effect, namely Europe's lack of presence in the innovation-based growth sectors.[9]

Table 4
Yollies in innovation-based growth sectors

	Europe	US
Share of yollies in IBG sectors	62	84
RDI of yollies in IBG sectors	13.9	12.6
RDI of region in IBG sectors	12.0	10.0

Source: Based on R. Veugelers, M. Cincera: Young Leading Innovators and EU's R&D intensity gap, Bruegel Policy Contribution 2010/09, Bruegel, Brussels 2010.

Explaining Europe's age and sectoral structural innovation deficit

Why are there fewer companies starting up and growing into world-leading innovators that spend sufficient resources on R&D to make it onto the Scoreboard of the largest R&D spenders? And why is this happening relatively less often, compared to the US, in new technology-based sectors, particularly biotechnology and ICT?

The most frequently cited explanation for the differences in dynamic structure between Europe and the US is a greater willingness on the part of US financial markets to fund the growth of new companies in new sectors.[10] Evidence from the German Community Innovation Survey confirms the importance of financial constraints for innovating companies in general, and particularly for young innovating companies.[11] Young highly innovative companies report on average higher obstacles to innovation than other innovating firms. Financial constraints – both internal and external – are the main barriers to innovation for young highly innovative companies. Although this also holds for other innovating firms, the differential is largest for younger companies. Cincera, Ravet and Veugelers examine econometrically the financial constraints faced by world-leading R&D investors.[12] Their analysis confirms that over the last decade, younger leading innovators appear to be more affected by financing constraints than their older counterparts, particularly in the EU.

Although the evidence clearly supports the importance of access to finance for highly innovative growth projects, the evidence also shows that one can nevertheless not ignore the importance of other impediments to innovation which reduce the expected rates of return on R&D investments. These other barriers relate to problems in the demand for innovations, regulatory burdens, access to skills and problems in partnering.[13] Cincera and Veugelers examine econometrically the rates of return to R&D investments for world-leading R&D investors.[14] They find that, while young firms in the US succeed in realising significantly higher rates of return to R&D as compared to their older counterparts, European

8 Europe specialises its R&D in sectors characterised as medium R&D-intensive (see P. Moncada-Paterno-Castello, C. Ciupagea, K. Smith, A. Tubke, M. Tubbs, op. cit.). These include automobiles, chemicals, electrics, industrial machinery and telecom services. All of them are older, medium R&D-intensive sectors. Furthermore, automobiles, chemicals and electrics are sectors with below-average R&D growth.

9 See also R. Veugelers, M. Cincera: Europe's Missing . . . , op. cit.

10 M. O'Sullivan, op. cit.

11 C. Schneider, R. Veugelers: On Young Highly Innovative Companies: why they matter and how (not) to policy support them, in: Industry and Corporate Change, Vol. 19, No. 4, 2010, pp. 969-1007.

12 M. Cincera, J. Ravet, R. Veugelers: R&D financing constraints of younger aged leading innovators in the EU and the US, in: Economics of Innovation and New Technology, forthcoming.

13 C. Schneider, R. Veugelers, op. cit.

14 M. Cincera, R. Veugelers: Differences in the rates of return to R&D for European and US Young Leading R&D firms, in: Research Policy, Vol. 43, No. 8, 2014, pp. 1413-142.

firms fail to generate significant rates of return, even if they are yollies and even if they are in high-tech sectors.

All this is a strong reminder that the innovation deficit in Europe is systemic. Access to finance cannot be tackled in isolation but should be embedded in an innovation environment that also addresses the other barriers to innovation. As these other barriers reduce the expected rates of return on highly innovative projects, they affect the appetite of financers to provide funds for these projects.

Recommendations for innovation policy making in Europe

The evidence presented in this contribution has important implications for Europe's innovation policy agenda. The evidence suggests that policies aimed at raising R&D expenditure across all types of industries and companies does not address the root causes of Europe's innovation deficit. To do this, policies need to address the specific barriers to development of new high R&D-intensity sectors and companies, as the evidence has shown how pivotal these sectors and companies are for tackling Europe's innovation deficit.

What types of policy interventions are needed in Europe to address these specific barriers? And how targeted do they need to be? A first important remark is that a general innovation policy aimed at improving the environment for innovation remains necessary. Because yollies need to interact with other innovators, and because innovators should not be impeded while they mature, a policy to address the lack of young companies in young R&D-intensive sectors needs to fit into a comprehensive innovation policy. This innovation policy should further the integration of the European capital, labour, product and services markets; make it easier for players in the innovation system to interact; and, at the same time, ensure healthy competition.

Such a comprehensive innovation policy will be necessary, but it will not be sufficient. Policy measures are also needed to tackle the specific barriers faced in new sectors by new companies. This includes inter alia access to external financing for fast-growing, highly innovative projects, through public funding and/or by leveraging private risk funding. First and foremost, the fragmentation in the EU venture capital (VC) market should be addressed: the critical size for a viable, fluid, thick European VC market can only be reached when VC markets operate at an integrated European scale and are open to the world. Beyond furthering the single market for risk financing, a system of grants for high-risk, innovative projects by young companies during their critical start-up and development stages – when financial market barriers are at their highest – cannot be missing in the set of EU instruments.

At this stage of the analysis, when there are still too many unknowns about whether and which interventions are effective for which countries, policy makers are advised to engage in close monitoring of emerging innovative markets. This will help to determine whether the right mix of policy instruments is present in the country and if the mix is effective for ensuring the smooth development of companies in new markets. Furthermore, policies that are shown to be ineffective in other markets can be adapted or abandoned altogether. Monitoring should include a strong prospective angle, able to identify new emerging markets well in advance so that a pro-active policy mix can be identified for the very earliest phases of development, when the risk of market failure is at its highest.

Rainer Frietsch, Christian Rammer and Torben Schubert

Heterogeneity of Innovation Systems in Europe and Horizon 2020

The US is still the most important national science and research system in the world, with China quickly catching up – not only in terms of quantity, but also in terms of quality. Europe, however, as the largest transnational science and research system, is ahead of these national systems. Recent analysis suggests that the European Union as a whole overtook the US with respect to the performance of the science system.[1] This is not only due to

1 European Commission: Innovation Union Scoreboard 2014, Brussels 2014; C. Rammer, B. Aschhoff, D. Crass, T. Doherr, M. Hud, C. Köhler, B. Peters, T. Schubert, F. Schwiebacher: Innovationsverhalten der deutschen Wirtschaft – Indikatorenbericht zur Innovationserhebung 2013, Centre for European Economic Research (ZEW), Mannheim 2014.

input factors but also to an increase in output. Meanwhile, the US has continuously lost ground in recent years, as is continuously exemplified by the results of the Innovation Indicator.[2] One reason for this gradual decline can be attributed to the country's science and research policy, which is traditionally designed as non-interventionist and market-conforming and envisions a rather passive role for the state. One result of this policy was that for many years public spending on science and research in the US did not increase at the same rate as it did in most other highly developed countries. In addition, the US struggled with the economic and financial crises, and other policy areas had priority over science and research. Even the US economic stimulus package, which envisaged a slightly more active role for science and research policymaking, was only able to produce a flash in the pan, leaving the overall trend hardly affected.[3]

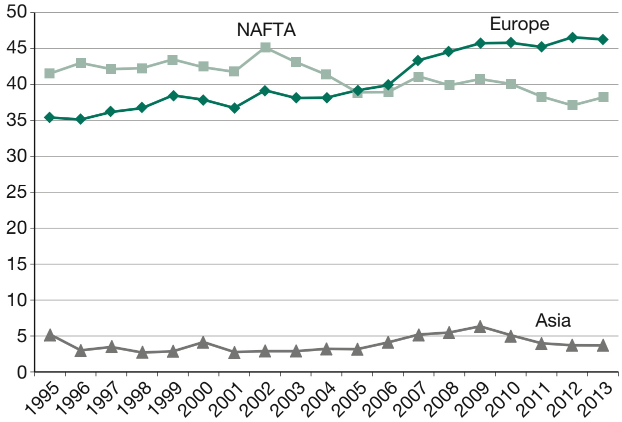
The Framework Programme as promoter of the European innovation system

The European Framework Programmes, on the other hand, were able to provide stability and growth, both in terms of funding as well as in terms of a political message that placed a high priority on science and technology – a message that was well received in almost all member countries. On top of this, the overall budget of the Framework Programmes has increased over the past decades. While Europe, as the largest transnational innovation system, has been struggling through an economic crisis, recent analyses have shown that in the field of science and research, Europe as a whole is actually far from being outperformed by the US. Both the input and output dimensions were upgraded in the last decade.[4] It is important to note that the overall upgrade of the European innovation system has, first and foremost, been caused by national efforts, of course. The main drivers of the European improvements were the Scandinavian countries and the larger central and western European countries, among them Germany, which has increased its public and private R&D spending since the mid-2000s from 2.5 to almost three per cent of GDP.

Figure 1

Scientific capabilities for three economic areas

Index values



Note: The economic area "Europe" consists of Austria, Belgium, the Czech Republic, Denmark, Finland, France, Germany, the UK, Greece, Hungary, Ireland, Italy, the Netherlands, Norway, Poland, Portugal, Spain, Sweden and Switzerland; NAFTA consists of the US, Canada and Mexico; and "Asia" consists of China, India, Indonesia, Japan, Singapore, South Korea and Taiwan.

The indicator can take on values between 0 and 100.

Source: T. Schubert, C. Rammer, R. Frietsch: Innovationsindikator 2014, Deutsche Telekom Stiftung, BDI, Deutsche Telekom Stiftung, Bonn 2014.

In a recent study, we analysed the innovative and scientific capabilities of supranational systems.[5] The results suggest that Europe has a slight advantage compared to the NAFTA countries (USA, Canada, Mexico) and Asia in terms of scientific capabilities (see Figure 1), as well as in terms of overall innovative capabilities (not depicted here). According to this data, Europe surpassed North America in the mid-2000s. North America was rather stable in the 1990s, lost some ground in the early 2000s and then, after another period of stability, lost further ground beginning at the end of the last decade. Asia, on the other hand, was able to slowly catch up in the 2000s, but recently it has also lost ground.[6]

It is not within the scope of this paper to provide unequivocal evidence on a causality link between Framework Programme activities and the upgrading of the European innovation system. The developments presented here nevertheless suggest that the policies implemented at the

2 R. Frietsch, C. Rammer, T. Schubert, S. Bührer, P. Neuhäusler: Innovationsindikator 2012, Deutsche Telekom Stiftung, BDI, Deutsche Telekom Stiftung, Bonn 2012; T. Schubert, C. Rammer, R. Frietsch, P. Neuhäusler: Innovationsindikator 2013, Deutsche Telekom Stiftung, BDI, Deutsche Telekom Stiftung, Bonn 2013; T. Schubert, C. Rammer, R. Frietsch: Innovationsindikator 2014, Deutsche Telekom Stiftung, BDI, Deutsche Telekom Stiftung, Bonn 2014; M. Weissenberger-Eibl, R. Frietsch, H. Hollanders, P. Neuhäusler, C. Rammer, T. Schubert: Innovationsindikator, Deutsche Telekom Stiftung, BDI, Deutsche Telekom Stiftung, Bonn 2011.

3 T. Schubert et al.: Innovationsindikator 2013 . . ., op. cit.

4 European Commission: Innovation Union Scoreboard 2014 . . ., op. cit.; C. Rammer, B. Aschhoff, D. Crass, T. Doherr, M. Hud, C. Köhler, B. Peters, T. Schubert, F. Schwiebacher, op. cit.

5 T. Schubert et al.: Innovationsindikator 2014 . . ., op. cit.

6 Countries not included in this depiction, such as those in Oceania and South America, were also able to improve their relative performance.

European level at the very least did not have a negative impact on European science and research performance in the past.

The continuation of the Framework Programme

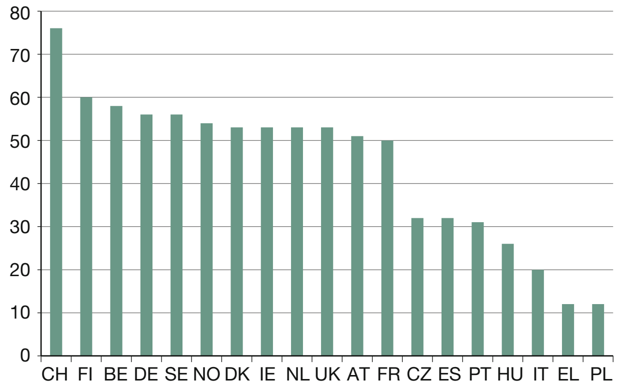
Horizon 2020 is a funding programme within the Innovation Union strategy. It supplants the European Commission's previous Framework Programmes for research, and its general aim is quite in line with the earlier Framework Programmes. The official documents of the Innovation Union state: "By improving conditions and access to finance for research and innovation in Europe, we can ensure that innovative ideas can be turned into products and services that create growth and jobs."[7]

Nonetheless, the Innovation Union also brings new focal points. The new Framework Programme Horizon 2020 integrates various EU funding activities for research and innovation, stressing two important aspects. The first emphasis is on the simplification and streamlining of the application and granting procedures, especially through the use of a single set of rules applicable to all funding activities. Additionally, with regard to funding for SMEs, a one-stop shop for the application and thus a lower administrative burden for applicants is intended. In this context, it is also interesting to note that "for each of the societal challenges, topic descriptions in calls for proposals will, more than in the past, allow plenty of scope for applicants to propose innovative solutions of their own choice."[8] This is an indication of greater flexibility and a bottom-up approach to finding solutions.

Second, Horizon 2020 also stresses that excellence in the European science and research system means competitive calls for proposals and independent selection procedures that are determined solely according to the criteria of quality and capability, "without any consideration of geographical distribution".[9] Furthermore, a stronger differentiation between the research funding in Horizon 2020 and the EU Structural Funds (development funds for structurally and economically disfavoured regions) is also intended.

This is a strong demarcation point as concerns the distributional aspects of the funding approach. While the preceding Framework Programmes had a pronounced

Figure 2
2014 Innovation Indicator results



Note: The Innovation Indicator can take on values between 0 and 100.
Source: T. Schubert, C. Rammer, R. Frietsch: Innovationsindikator 2014, Deutsche Telekom Stiftung, BDI, Deutsche Telekom Stiftung, Bonn 2014.

cohesive component, Horizon 2020 adopts the notion of excellence that was previously present in such an exacting manner in only some selected mechanisms of the European Research Area, particularly in the context of funding provided by the European Research Council.

Concerning administrative simplifications, it needs to be seen if procedures and selection processes can indeed be streamlined and if administrative rules are supportive of this high aim of increasing efficiency. Concerning excellence, the strict focus on quality and scientific rigorousness – while abandoning the aim of geographically balanced participation – is a new avenue which may bring new political challenges given the heterogeneity of member states and regions within the EU in terms of their science bases and innovative capacities.

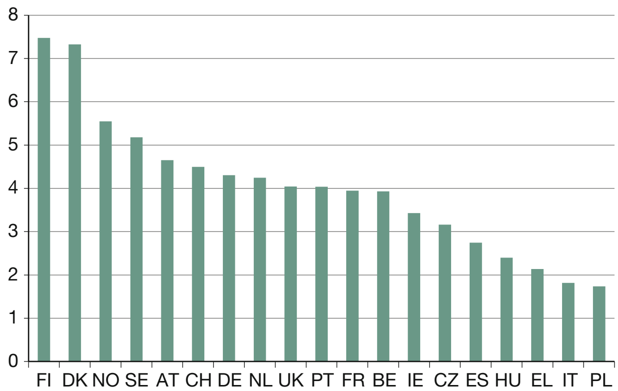
Heterogeneity of innovation in Europe

Several composite innovation indicator systems have analysed the differences in the national innovation capabilities across European countries. Examples are the Innovation Union Scoreboard and the Innovation Indicator.[10] Both measurement frameworks find that innovation capabilities differ fundamentally among member states (see Figure 2). In the Innovation Indicator, which can take on values between 0 and 100 points, Switzerland is the best performer with 76 points, while the majority of western EU member states hover around 50-60 points. Southern and Eastern European countries perform much worse, with values far down the scale. Spain and the Czech Republic score 32 points, Italy 20, Greece 12 and Poland 12. As a point of

7 European Commission: Innovation Union. A pocket guide on a Europe 2020 initiative, Publications Office of the European Union, Luxembourg 2013, p. 8.
8 European Commission: Horizon 2020 – The Framework Programme for Research and Innovation – COM(2011) 808 final, Brussels 2011, p. 9.
9 Ibid., p. 11.

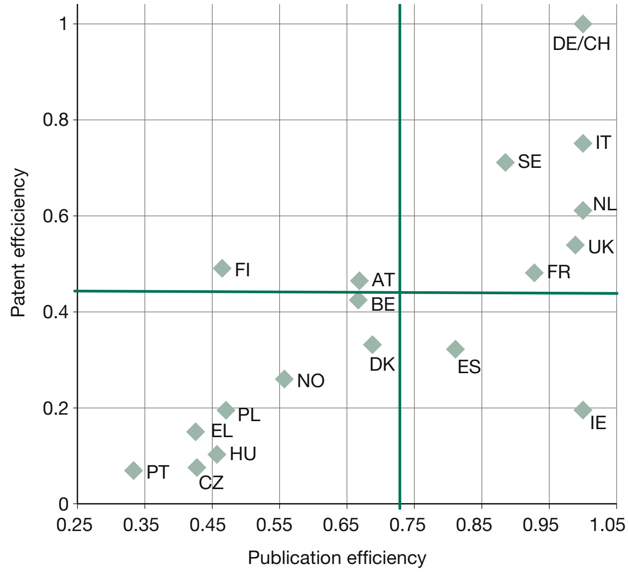
10 European Commission: Innovation Union Scoreboard 2014 ..., op. cit.; T. Schubert et al.: Innovationsindikator 2014, op. cit.

Figure 3
Researchers per 1000 inhabitants



Source: Own calculations based on OECD data.

Figure 4
DEA-VRS patent and publication efficiencies



Note: The DEA methodology is based on a benchmarking approach. As such, the fact that the top countries in the sample achieve a value of 1 does not imply that they cannot do anything to improve their efficiencies.

Source: Own calculations based on data from OECD, Web of Science, PATSTAT.

reference, China clocks in at 29 points and South Africa at 10. While this suggests that the Western and Northern European countries have well established and strong innovation systems, the Southern and Eastern European countries are much weaker, and some of them do not even exceed the levels of threshold countries.

While this result casts some initial doubts on whether all countries are likely to benefit from Horizon 2020 funding, it should be noted that the overall performance of the countries can be split into an input component and an output component. The first measure indicates how much a country invests into its innovation system, and the latter one gives an indication of how effectively this investment is used. When separating by these two dimensions, it becomes evident that countries that perform low in the overall Innovation Indicator also rank low in their level of inputs. Figure 3 displays the total research personnel (in science and enterprises) per 1000 inhabitants. Once again, it is mainly the Southern and Eastern European countries that rank low on this indicator.

While the low levels of input could provide a basis for arguing that Horizon 2020 may contribute to a remedy to the underinvestment problem, a look at the efficiency of the use of inputs suggests that "underinvestment" is largely a response to low resource efficiency.

In order to identify resource efficiency, we analysed the ability of national innovation systems to generate transnational patents – i.e. patents filed at the European Patent Office or the World Intellectual Property Organization[11] – and scientific publications in relation to the countries' number of researchers in companies and in the public science system. We used data envelopment analysis to calculate the variable returns to scale efficiencies, which take on a value of 1 if a country reaches the highest possible value of output for a given level of input and 0 if it generates no output. Again, we see tremendous heterogeneity among countries (see Figure 4). Switzerland and Germany reach the maximum efficiency of 1 in both dimensions – i.e. they make the best possible use of the given resources – while a large number of countries are below average (the green horizontal and vertical lines) in both dimensions. This primarily concerns countries in Southern and Eastern Europe, although Italy is a remarkable exception, as it achieves relatively high efficiencies in both dimensions.

This finding has two important implications. First, the low R&D investment levels in many Southern and Eastern European countries are not the result of underinvestment (which may be tackled by providing additional funds through Horizon 2020) but are rather a rational response to relatively low capabilities to transfer research investment into research output. Second, for the efficiency of funding provided through Horizon 2020, this implies that the expected outputs from a given amount of resources will differ widely by country of destination. Take Portugal's patent efficiency of 0.07, for example. There are benchmarks in the sample that use the same level of inputs to generate a patent output that is ten times higher.

11 R. Frietsch, U. Schmoch: Transnational Patents and International Markets, in: Scientometrics, Vol. 82, No. 1, 2010, pp. 185-200.

While the heterogeneity in publication efficiencies is not as large, this bears important insights for the potential of Horizon 2020 to create technological breakthroughs. First, it stands to reason that the Horizon 2020 plan will only be able to initiate the radical innovative renewal that is its goal if resources are concentrated in those countries that are best able to make efficient use of them. Simply reshuffling research funding to the innovative periphery in Europe will not solve the problem of low innovativeness, as this is (with the exception of Italy) not caused by underinvestment in R&D but by low innovative capabilities. Second, if the project selection process in the Horizon 2020 programme continues to allocate funding based not on excellence and expected output but on geographical considerations – a practice for which EU innovation funding has long been known – this might upgrade the innovation capabilities in the weaker countries in the very long run. But in the short run, i.e. through 2020, this will most likely not lead to a substantial increase in the production of new knowledge and technologies needed for regaining competitiveness and job growth in the long run. Therefore, it is highly welcome that the Innovation Union strategy stresses a stricter demarcation between EU Structural Funds and the funding of science and research via the Horizon 2020 framework.

Conclusion

Without any doubt, there is a strong need for continued economic growth and greater generation of jobs in Europe. Research and innovation are integral and important contributors in achieving these goals and are thus rightfully emphasised by the Innovation Union and even more so by its funding programme Horizon 2020. The two main lines of action that we have discussed in this paper, namely increasing the efficiency of the application and granting procedure and focusing science and research funding on excellence, are reasonable and consistent with this overall goal. There is considerable heterogeneity of the science and innovation systems in Europe, not only with respect to their resource endowment but also with respect to their efficiency in producing scientific and innovative outputs. However, we expect that if the Horizon 2020 programme actually follows its rhetoric and focuses on funding world-class researchers and disruptive research in enabling industrial technologies, some member states will benefit more from these investments than others. Therefore, Horizon 2020 will likely increase the heterogeneity of innovation systems in Europe, while its impact on growth and jobs will hardly target those countries that would need them most urgently. We also expect, however, that the aims of excellent research, increased growth and job creation are better attainable by Horizon 2020 across the whole of Europe by foregoing the goal of reduced heterogeneity. In the longer perspective, a general upgrade of science and innovation and an increase in the number of research and innovation-oriented member states is a worthwhile pathway. As such, this new approach in Horizon 2020 is especially promising, even for the countries that are less oriented towards science and innovation.

Anita Pelle*

Mind the Gap: Arguments in Favour of Judicious Constructivism in Providing Horizon for All

Maximising the competitiveness impacts of research and innovation is among the three strategic objectives of Horizon 2020, the EU's research and innovation programme for the 2014-2020 period. According to the programme document, Horizon 2020

> will raise the level of excellence in Europe's science base and ensure a steady stream of world-class research to secure Europe's long-term competitiveness. It will support the best ideas, develop talent within Europe, provide researchers with access to priority research infrastructure, and make Europe an attractive location for the world's best researchers.[1]

* The research on which this article is based has been carried out in the framework of the project titled "Need for a competitiveness union in the EU", project ID: 553486-EPP-1-2014-1-HU-EPPJMO-CHAIR. All support is gratefully acknowledged. The author also owes her thanks to her two research assistants, Renáta Laczi and Marcell Zoltán Végh, for their freshness, precision and commitment.

1 European Commission: Horizon 2020 – The Framework Programme for Research and Innovation, COM(2011) 808 final, 30 November 2011, Brussels. The quote is from the description of the priority "Excellent Science" on p. 4.

Table 1
Subindex weights and income thresholds for stages of development

	Stage of development				
	Stage 1: Factor-driven	Transition from stage 1 to stage 2	Stage 2: Efficiency-driven	Transition from stage 2 to stage 3	Stage 3: Innovation-driven
GDP per capita (USD) thresholds	<2000	2000-2999	3000-8999	9000-17000	>17000
Weight for basic requirements (%)	60	40-60	40	20-40	20
Weight for efficiency enhancers (%)	35	35-50	50	50	50
Weight for innovation and sophistication factors (%)	5	5-10	10	10-30	30

Source: WEF: The Global Competitiveness Report 2014-2015, Geneva 2014, p. 10.

However, even the European documents acknowledge discrepancies. The interim evaluation of the Seventh Framework Programme for Research (FP7) has been the most honest so far,[2] finding that the leading recipients of FP7 funding were based in a relatively small number of member states, that the top 50 recipients (none of whom were from the new member states) secured around a quarter of all funding and that new member states' participation fell short of that of the old member states.[3] The expert group that drafted the FP7 interim report concluded that these imbalances are due to specific problems of national research landscapes and the smaller number of world-class institutions in these countries, issues to be studied in further detail. One might wonder where those further studies are. Brain drain as "a sensitive policy question" is also mentioned – and subsequently ignored.[4]

At the same time, the research and innovation programme documents have repeatedly emphasised that the development of territories lagging behind, including in terms of research and innovation, is beyond the policy's (and thus Horizon 2020's) scope. They recommend that the issue should instead be tackled by cohesion policy (mainly through the Structural Funds). There are a few problems with this approach, and we mention only one here, namely that the implementation of cohesion policy is placed in the member states' hands, which does not necessarily serve the targeted purpose, given the poor institutional quality in many of these countries. Indeed, this is one of the main reasons that they are lagging behind. Chapter 8 of the Horizon 2020 programme document, paradoxically titled "Spreading excellence and widening participation", starts with the claim that selection will continue to be "merit-based", "without any consideration of geographical distribution".[5] So much for spreading and widening. The document goes on to repeat that cohesion policy will do the job here. Sounds great.

Furthermore, the impact assessment of Horizon 2020 seems to apply a strikingly narrow approach to competitiveness, as it measures "economic and competitiveness impacts" solely in terms of increased GDP, extra export formation and decreasing imports.[6] The programme document itself does not explain what it means by competitiveness in any way. In fact, competitiveness can be interpreted in several ways. In this article, we use the concept applied by the World Economic Forum (WEF) in constructing the Global Competitiveness Index (GCI), as we agree with the economics behind it.[7] The WEF uses 114 sub-indicators, a combination of hard data and outcomes of the Executive Opinion Survey. The sub-indicators are arranged under 12 pillars. According to the WEF, there are three stages of development (factor-driven, efficiency-driven and innovation-driven), but transition from one to another is smooth (and not trivial). As countries climb the development ladder, the importance of innovation and business sophistication increases. Accordingly, the WEF considers these with greater weights at higher stages of development, reaching 30 per cent in the innovation-driven stage (see Table 1).[8]

2 R. Annerberg, I. Begg, H. Acherson, S. Borrás, A. Hallen, T. Maimets, R. Mustonen, H. Raffler, J.-P. Swings, K. Ylihonko: Interim Evaluation of the Seventh Framework Programme – Report of the Expert Group, European Commission, Stockholm, Brussels 2010.

3 The same patterns can be found in the European Institute of Innovation and Technology's Knowledge and Innovation Communities and in most of the High Level Groups working on research and innovation-related analyses and reports. See http://eit.europa.eu/eit-community/map.

4 R. Annerberg et al., op. cit., p. 47.

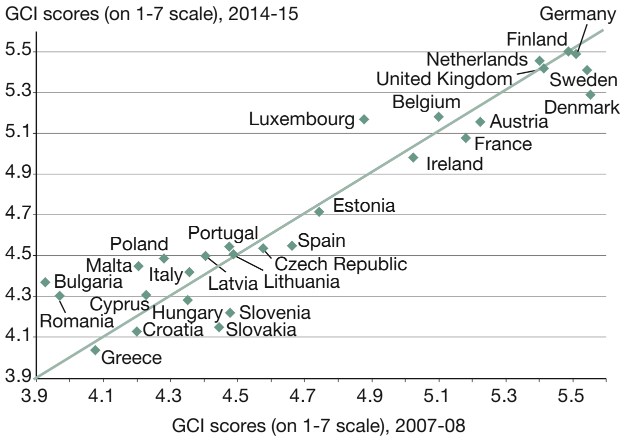
5 European Commission, op. cit., p. 11.

6 European Commission: Impact Assessment Accompanying the Communication from the Commission 'Horizon 2020 – The Framework Programme for Research and Innovation', SEC(2011) 1427 final, 30 November 2011 Brussels, p. 27, 30 (Box 10).

7 X. Sala-i-Martín: The Economics Behind the World Economic Forum's Global Competitiveness Index, in: P. De Grauwe (ed.): Dimensions of Competitiveness, Cambridge, MA 2010, MIT Press, pp. 1-18.

8 WEF: The Global Competitiveness Report 2014-2015, Geneva 2014.

Figure 1
The competitiveness of EU member states



Source: Own calculations based on WEF GCI dataset.

Competitiveness of EU member states and the internal competitiveness gap

In the WEF's 2014-2015 Global Competitiveness Report, EU member states are distributed among the three upper stages of development.[9] Bulgaria and Romania, despite their relatively favourable overall ranks (54 and 59 respectively), are still in the efficiency-driven stage (along with 28 other economies worldwide). There are 24 economies in the group of countries in transition from stage 2 (efficiency-driven) to stage 3 (innovation-driven), of which five are EU member states: Croatia, Hungary, Latvia, Lithuania and Poland. The remaining 21 EU member states belong to the 37 innovation-driven economies of the world. Some of the EU member states are world leaders in competitiveness: Finland (4), Germany (5), the Netherlands (8), the United Kingdom (9) and Sweden (10) are in the top ten. Among the innovation-driven EU member states, only Estonia (29) and the Czech Republic (37) are post-socialist economies.

Figure 1 shows the rankings of EU member states according to the GCI at the beginnings of the previous (2007-2014) and current (2014-2015) EU programming periods.[10] The figure clearly shows the gap between the core (that is, the North and West) and the periphery (South and East) of the EU. Additionally, the periphery has become a smooth combination of the Southern eurozone periphery and the new member states; no borderline can be drawn between these two country groups any more.

The countries under the diagonal performed more poorly on the latest GCI than they did seven years earlier, while those above the diagonal were able to improve their performance over the same time period. We can see that just as many countries are found under the line as above it (14-14). Nevertheless, there have been some significant changes in both absolute and relative positions. The considerable improvements by Bulgaria (+0.44 points) and Romania (+0.33 points) along with the declines in Denmark (-0.27 points) and Sweden (-0.13 points) considerably reduced the overall range of EU member states' GCI scores in the reference period (from 1.63 points in 2007-2008 to 0.92 points in 2014-2015). At first glance, this could be good news, as it may imply that the EU has become less heterogeneous in terms of competitiveness. On the other hand, the fact that Greece now brings up the rear of EU competitiveness rankings with a score slightly lower than seven years ago, together with the worsening of France's performance (-0.10 points) and some large declines in the periphery, especially in Slovakia and Slovenia (-0.30 and -0.26 points respectively), does not leave much room for celebration.

Further aspects of internal imbalances in the EU in relation to research and innovation

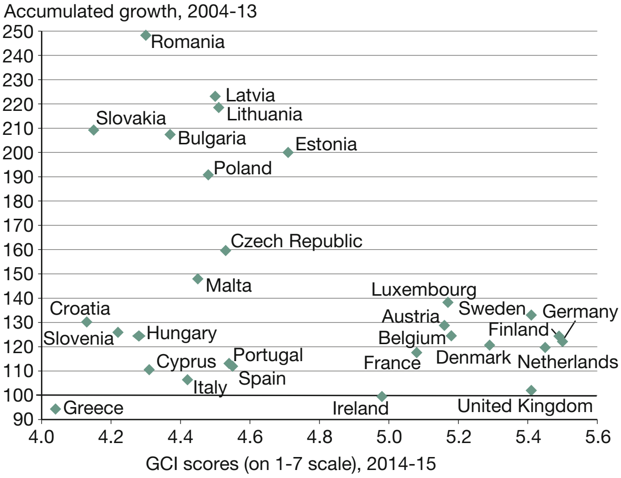
As the WEF claims, competitiveness is ultimately a means of achieving and maintaining economic growth. As discussed above, research and innovation play a crucial role here; thus, it might be worth taking a look at the real growth and R&D performances of EU member states. Figures 2 and 3 show the accumulated growth of EU member states from 2004 to 2013 and 2007 to 2013 respectively, in terms of their most recent GCI scores (2014-15).

What do the figures tell us? Firstly, over the 2004-13 time horizon shown in Figure 2, Greece had a smaller GDP at the end than it did at the beginning, and Ireland and the UK's GDPs remained practically unchanged. However, the time horizon covered by Figure 3, which begins in 2007, i.e. shortly before the outbreak of the financial crisis, shows that the United Kingdom, Cyprus, Spain, Italy and Portugal also all had smaller GDPs in 2013 than they did six years earlier.

Secondly, the 2004-13 comparison shows that many of the post-socialist new member states (in fact, all of them but Hungary, Slovenia and Croatia) largely outperformed the rest of the EU in terms of GDP growth (including those countries obtaining much higher GCI scores). Ro-

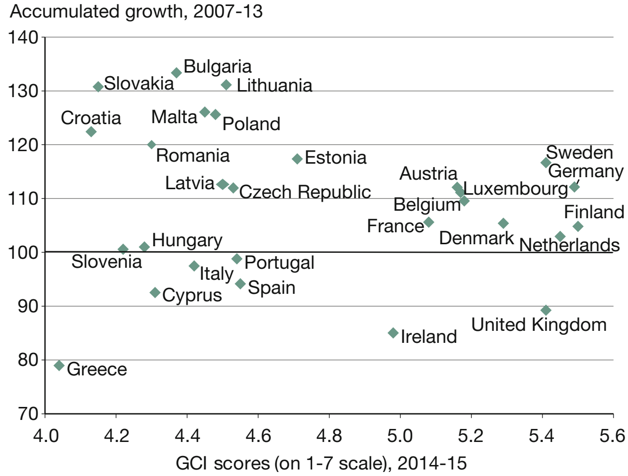
9 WEF, op. cit., p. 11.
10 In our analysis, we include all current 28 member states, including pre-accession data for Romania, Bulgaria and Croatia.

Figure 2
EU member states' real GDP growth (2004-13) in terms of their 2014-15 GCI scores



Sources: Own calculations based on WEF GCI dataset and Eurostat.

Figure 3
EU member states' real GDP growth (2007-13) in terms of their 2014-15 GCI scores



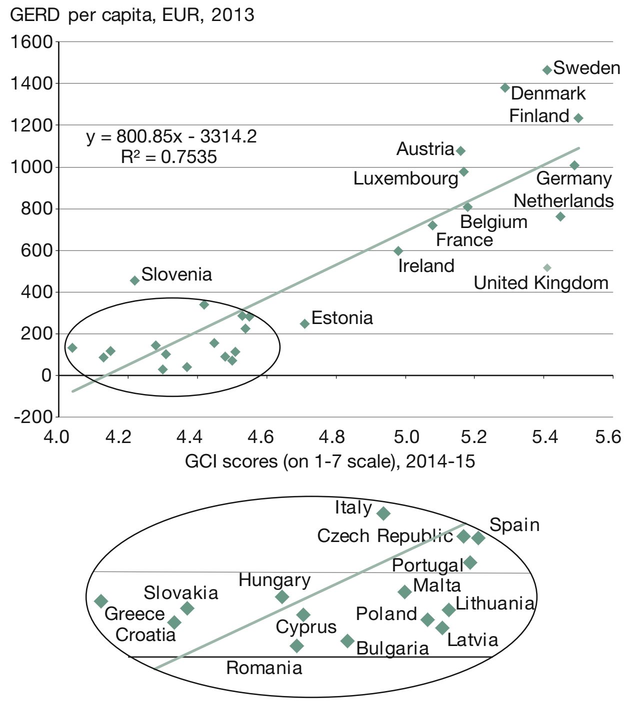
Sources: Own calculations based on WEF GCI dataset and Eurostat.

mania (248 per cent), Latvia (223 per cent) and Lithuania (219 per cent) stand out even among the fast-growing Eastern new member states. However, Figure 3 illustrates that the performances are no longer so impressive if we use 2007 as our starting date. Indeed, even the best performing countries (Bulgaria, Lithuania and Slovakia) are only just above the 130 per cent level. This can be only partly explained by the shorter time period. Much more significant were the deleterious effects of the financial crisis. The overall conclusion that can be drawn is that the crisis led to a break in the earlier continuous convergence of the less developed countries.[11]

What about the role of R&D expenditures in the competitiveness of EU member states? Figure 4 shows the relation. We obtained R&D expenditures through the gross expenditure on research and development (GERD) per capita indicator (in order to exclude the "size effect"), and we continued to use the GCI as our indicator of competitiveness. The relation is positive and rather strong (R^2=0.75 in linear regression), and the countries can again be divided into two groups: the core and the periphery. The span of the GERD per capita data is quite striking, ranging from €27.90 in Romania to €1464.50 in Sweden. In this respect, the periphery is more homogeneous than the core, but this is only due to the low levels of R&D expenditures in the periphery as a whole. In fact, 11 of the 17 countries in this group are below the trend line in this figure. As regards the core countries, the United Kingdom stands out with the lowest per capita R&D expenditures coupled with the fourth best score on the GCI index. Obviously, the competitiveness of the UK is driven by factors other than R&D expenditures.

11 The same conclusion is drawn by EBRD: Transition Report 2013 – Stuck in Transition?, London 2013.

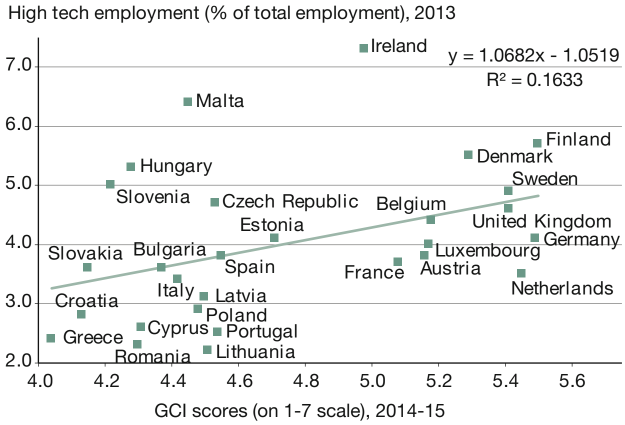
Figure 4
EU member states' GERD per capita in terms of their 2014-15 GCI scores



Sources: Own calculations based on WEF GCI dataset and Eurostat.

Figure 5

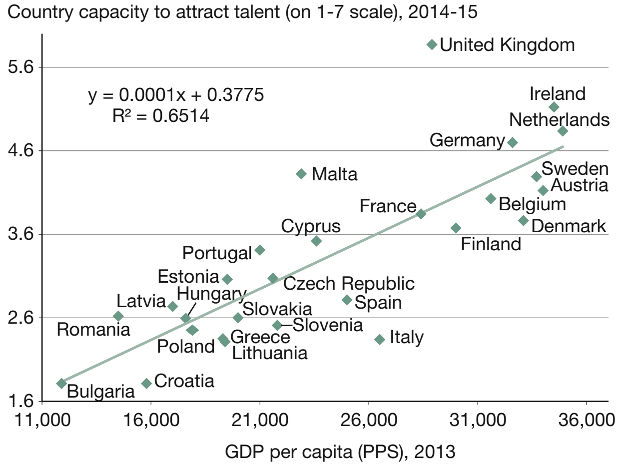
High-tech employment in EU member states in terms of their 2014-15 GCI scores



Source: Own calculations based on WEF GCI dataset.

Figure 6

EU member states' capacity to attract talent



Note: Luxembourg is excluded due to excessively high GDP per capita data.

Sources: Own calculations based on WEF GCI dataset and Eurostat.

One of our initial hypotheses was that a similarly strong positive correlation exists between competitiveness and the share of high-tech employment (both manufacturing and services) in per cent of total employment. However, the result of our investigations (see Figure 5), led us to throw out this hypothesis. Not even the core-periphery divide is traceable in the shares of high-tech employment. Apparently, employment patterns develop along different dimensions – ones outside the scope of this article.

Let us examine another aspect of internal imbalances: human talent. We consider it of crucial importance but, unfortunately, it is rather neglected at the EU policy level (despite the nice superficial rhetoric). The success of research and innovation is largely determined by how much human talent is discovered, nurtured, developed and exploited. How are member states performing in this respect?

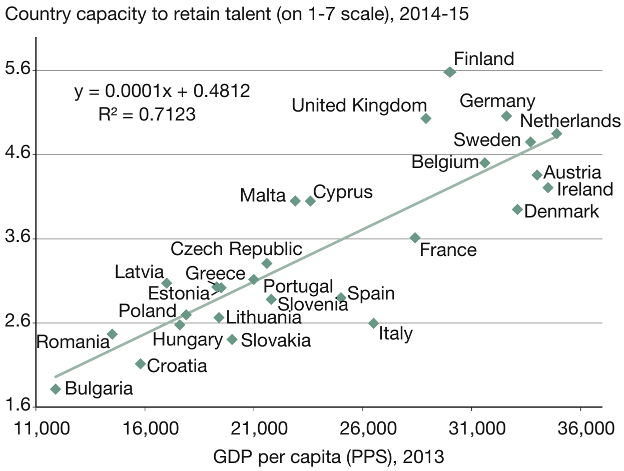
To find out, we take two sub-indicators from the GCI: country capacity to attract talent and country capacity to retain talent. Both of these indicators derive from the WEF Executive Opinion Survey. As these are two of the 114 sub-indicators constructing the GCI, we use GDP per capita as a reference. We use the PPS data, which provides a fairer and more accurate picture than the nominal data. Figures 6 and 7 reveal surprisingly strong positive correlations between GDP per capita and countries' capacities both to attract and to retain talent (R^2 equals 0.65 and 0.71 respectively in linear regression). EU member states can once again be easily divided into two groups, in both dimensions. The country groups are very similar to the ones from Figure 4,[12] although the internal relative positions of group members are somewhat different.

To point out the seriousness of the situation, we have included the population data of selected member states from the Eastern periphery and those of member states belonging to the core of the EU (Table 2). Even though Romania and Bulgaria only joined the EU in 2007, both countries have lost roughly seven per cent of their population in the reference period (2004-2013). Latvia and Lithuania suffered even greater losses (11.10 per cent and 12.56 per cent respectively). Overall, the six selected Eastern European countries have lost almost 3 million people, accounting for a 6.35 per cent decrease in their total population. We now also have reliable data underpinning the earlier intuitive concerns that, among those leaving these countries, people with higher education attainment would be largely overrepresented in relation to the home population.[13] In the same time period, the population of the core countries of the EU grew by more than 8 million people, representing growth of 3.45 per cent. Sweden led the group with a gain of 580,000 peo-

12 The capacity of Malta and Cyprus to attract and retain talent is comparable to that of the core countries.

13 For detailed analysis, see: H. Fassmann, E. Musil, K. Gruber: Dynamic historical analysis of longer term migratory, labour market and human capital processes in the SEEMIG region, SEEMIG Working Papers No. 3, August 2014; Hungarian Demographic Research Institute; and Z. Blaskó: Surveying the Absentees – Surveying the Emigrants, SEEMIG Working Papers No. 4, October 2014.

Figure 7
EU member states' capacity to retain talent



Note: Luxembourg is excluded due to excessively high GDP per capita data.

Sources: Own calculations based on WEF GCI dataset and Eurostat.

Table 2
Population and population change in selected EU member states

Country	Population 2004	Population 2013	Change (2013 - 2004)	Change (2013/2004)
Bulgaria	7,801,273	7,284,552	-516,721	-6.62%
Romania	21,521,142	20,020,074	-1,501,068	-6.97%
Hungary	10,116,742	9,908,798	-207,944	-2.06%
Estonia	1,366,250	1,320,174	-46,076	-3.37%
Latvia	2,276,520	2,023,825	-252,695	-11.10%
Lithuania	3,398,929	2,971,905	-427,024	-12.56%
Eastern periphery total	46,480,856	43,529,328	-2,951,528	-6.35%
Netherlands	16,258,032	16,779,575	+521,543	+3.21%
Germany	82,531,671	82,020,578	-511,093	-0.62%
UK	59,793,759	63,896,071	+4,102,312	+6.86%
France	60,505,421	63,659,608	+3,154,187	+5.21%
Finland	5,219,732	5,426,674	+206,942	+3.96%
Sweden	8,975,670	9,555,893	+580,223	+6.46%
Core total	233,284,285	241,338,399	+8,054,114	+3.45%

Source: Own calculations based on Eurostat data.

ple, representing a 6.46 per cent increase in the population.

An examination of the yearly dynamics of change shows that there are different tendencies in the two regions. While the Eastern periphery suffered the greatest population loss from 2007 to 2008 (630,000 people in the six selected countries) and the negative tendency has since slowed down (to 200,000 from 2012 to 2013), the population gain of the core countries has, with a few exceptions, continued to grow from year to year, exceeding a million new immigrants in both 2012 and 2013.

How can this situation be handled? One of the solutions lies in undertaking major investments in human capital. Equitable education could considerably help to remedy the discrepancies in nurturing talent across the EU. Unfortunately, quantitative and qualitative analyses show that while equity in education seems to characterise the core EU member states, this is not the case for the ones in the periphery.[14] Education should be placed in the forefront of research and innovation policy as the basic "edge" of the knowledge triangle: without the adequate human capital inputs, research and innovation in the periphery will never soar. However, education is regrettably neglected by the current European research and innovation policy.

Problem and possible solution

Annex I of the impact assessment accompanying Horizon 2020 simply states that "[t]he extent of involvement in the FP of individual EU Member States, associated countries, and EU regions is in line with their economic and research capabilities."[15] This is problematic for a number of reasons. Firstly, there is very strong back-and-forth causality: better research capabilities indeed lead to more funding, but more funding also yields better research capabilities (in an adequate institutional and programme setting, of course). Why is this latter relation ignored by EU policy? Of course, the role of path dependence cannot be denied, and miracles are not achieved from one day to the next. But public policy is meant to be path-creating rather than resigning itself to the "inevitable".

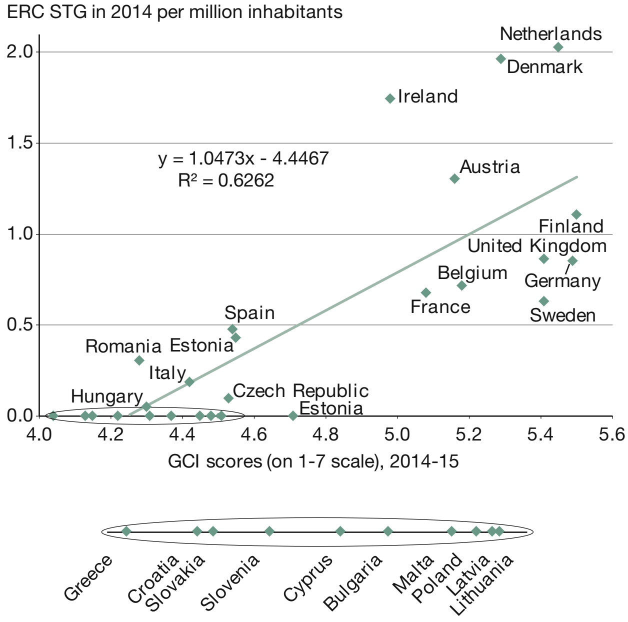
14 OECD: PISA 2012 Results: Excellence through Equity – Giving Every Student the Chance to Succeed, Vol. II, Paris 2013; B. Csapó, J. Balázs Fejes, L. Kinyó, E. Tóth: Az iskolai teljesítmények alakulása Magyarországon nemzetközi összehasonlításban, in: T. Kolosi, I.G. Tóth (eds.): Társadalmi Riport 2014, Budapest 2014, TÁRKI, pp. 110-136; J. Köllő: Patterns of Integration – Low Educated People and their Jobs in Norway, Italy and Hungary, IZA Discussion Paper No. 7632, September, Bonn 2013.

15 European Commission: Impact Assessment ..., op. cit., Annexes, p. 11.

Secondly, the impact assessment finds "very strong correlation" (0.98) between the magnitude of EU R&D funding received by a member state and the size of its economy. Is there anything surprising about this? Not really. The Annex of the impact assessment also shows how impressively high the percentages are for participation in FP7 in relation to countries' GERD per capita indicator. Such results are easily predictable but, unfortunately, do not tell us much.

Instead, we examine some different data. Figure 8 shows the relation between competitiveness (measured by the GCI) and the number of European Research Council (ERC) Starting Grants per million inhabitants awarded in December 2014. We can see that the two dimensions are positively and considerably correlated (R^2=0.63 in linear regression), and the largest deviations are upwards, by some of the most developed countries (especially the Netherlands and Denmark). The figure also shows that there are ten member states from the periphery which were awarded no ERC Starting Grants in 2014.[16] Thus, it would appear that business as usual continued in 2014, despite the lofty commitment made in the Horizon 2020 impact assessment to leave it behind.

Figure 8
ERC Starting Grants in terms of the 2014-2015 GCI scores



Sources: Own calculations based on WEF GCI dataset and ERC.

Conclusions and policy recommendations

What are the implications of the evidence presented in this article? Without a change in policy, where is all this likely to lead? Evidently not towards overall prosperity in the EU as a whole. Given that talent can be found anywhere with the same probability (why would it be any other way?), a logical conclusion is that the EU is wasting a lot of the human talent in its Southern and Eastern periphery (that is, in the majority of member states). Those talented humans that manage to move and employ their abilities in the core countries of the EU are "saved", but this method of exploiting talent (that we call brain drain, with good reason) will only further deepen the core-periphery imbalances. So, what can possibly be done to improve this current unfortunate situation?

In terms of EU-level research and innovation policy, the research and innovation environment in the periphery (including education) must be improved to make it more enabling and supportive. Moreover, ensuring fair chances for participation in the research funding programmes in a proactive way would be a minimum. This does not necessarily fit with the popular notion of the "level playing field", but in fact the current playing field is far from level, as we documented above. A levelling process could possibly start with an upgrade of the (education and) research and innovation environment in the periphery, instead of continuing to regard the current state of these capabilities as given that policy can do nothing to alter. The current attitude is ignorant and lacks wisdom and constructivism. Systemic institution building and participative capability development are existing techniques. As the Horizon 2020 impact assessment contends, business as usual is not a preferred strategy for the future. Not even in this respect.

If the EU does not face up to the reality of its internal imbalances honestly and bravely, and if it remains reluctant to integrate this reality into its research and innovation policy framework, the responsibility for the lost ideas, lost talents and lost innovations will also lie with the EU. The EU as a whole will have to pay the price for its ignorance via continuing fragmentation, a lack of growth and a failure to improve overall competitiveness in the global arena. These may be strong statements, but they are based on solid grounds and thorough reasoning.

The bottom-line question is whether the EU can afford such a waste of talents and innovation. Would it require significant efforts to improve the current situation? Yes, certainly, and it would need to be done in a smart way.

16 Luxembourg also received no ERC Starting Grants in 2014 but was omitted from the figure because it distorted the regression too much.

Would it be tiresome and time-consuming to create an adequately enabling environment for talent and excellence in the periphery of the EU as well, and not just in the core? Yes, it would, but it should be considered as an investment in our common future and not as an expenditure on "the weak and poor". All things considered, would it be worth leaving business as usual behind and becoming more judicious and constructive, both in planning and in implementation? We believe it would. Eventually, it would be in all of our interests to create a more integrated EU that makes far better use of its resources than it does today.

Andrea Renda

Europe and Innovation: Is 2020 on the Horizon?

The European Union entered into a stalemate in terms of innovation and entrepreneurship long before it was hit by the economic and institutional crisis that now monopolises the public debate. EU institutions have increasingly shown "performance anxiety" in trying to catch up with the growing gap between the EU and the United States in this field, claiming that Europe was experiencing a true innovation emergency.[1] Relevant data over the past few years have shown alarming trends, with Europe remaining a world leader only in terms of public money spent on research and development (R&D) and gradually losing its lead in most substantive innovation outcome indicators.[2] This has led to a proliferation of efforts at the EU level to spur innovation, from the launch of the Innovation Union flagship initiative within the Europe 2020 strategy to the setting of a specific long-term goal of reaching three per cent of public and private spending on R&D in the EU by 2020. One of the most visible projects is the Horizon 2020 programme, which devotes an unprecedented amount of financial resources to the joint promotion of research and innovation. Today, halfway through the decade-long Europe 2020 strategy and a year after the launch of Horizon 2020, the results are inevitably mixed and the available data open to interpretation.

In the 2014 Innovation Union Scoreboard, the European Commission announced that the EU has halved the gap with the US and Japan, although Korea continues to distance itself and China is quickly catching up.[3] Such findings, however, have to be weighed against the fact that innovation (and its related indicators) is only an intermediate outcome: its virtue lies in fostering productivity and growth and improving social welfare and well-being. In this respect, it is legitimate to ask whether Europe's timidly improving performance on the innovation scoreboard will pave the way towards growth or whether other actions would be needed to ensure that enhanced public and private R&D spending becomes an engine for economic recovery.

This short paper discusses the way in which innovation and entrepreneurship are changing and analyses the evolving role and scope of innovation policy in light of the exponential acceleration of technology expected between now and the end of the decade. The main argument put forward in this paper is that due to the advent of cloud computing, the Internet of Things and the increased virtualisation of phases of the value chain, innovation will occur in so many different ways that governments will be forced to focus on a limited number of very crucial roles, such as facilitating the flow of information and promoting the competitiveness of innovation platforms where needed. In this respect, even if it is too soon to draw any conclusion on a programme that only started a year ago, Horizon 2020 seems to bring laudable changes to the way in which the EU conceives of its innovation policy: the role of the European Institute of Innovation and Technology (EIT) should be further strengthened by linking European Innovation Partnerships to the EIT's Knowledge and Innovation Communities, as well as with the Joint Technology Initiatives foreseen under the new Horizon 2020 programme.

The paper also argues that the reallocation of funds from Horizon 2020 to the European Fund for Strategic Investment (EFSI) recently announced by the new President of the European Commission Jean-Claude Juncker is not necessarily bad news for EU innovation. What

1 See e.g. http://europa.eu/rapid/press-release_IP-11-692_en.htm.

2 See e.g. M. Granieri, A. Renda: Innovation Law and Policy in the European Union: Towards Horizon 2020, Springer, Milan 2012.

3 See the Innovation Union Scoreboard 2014.

might be more alarming, however, is the weaker emphasis being placed on innovation policy, which resulted in an apparently "thin" mandate being given to the new Commissioner for Science, Research and Innovation. In addition, the paper argues that urgent measures are needed on all those areas of the EU *acquis* that, despite not being labelled as innovation policy, exert a strong influence on the level of innovation and entrepreneurship observed in the European economy – namely competition law, education policy, red tape reduction and investment in infrastructure.

The changing nature of innovation

Until a couple of years ago, most of the debate about the lack of innovation in Europe focused on the absence of a common patent system, which according to many commentators was inhibiting innovative efforts by European SMEs. Today, despite considerable progress and a long-awaited political agreement, no one would claim that Europe's innovation problem will be significantly closer to a solution once the unitary patent and the Unified Patent Court are in place. Our understanding of innovation has improved over the past several years: today, the complexity of the innovation ecosystem is changing the way we look at innovation policy (to the extent that innovation can be termed as a "policy" anymore). A consensus has emerged that several concomitant ingredients have to be present for the recipe to work.

First, innovation is increasingly less related to R&D spending. A newly emerging phenomenology of innovation contemplates many forms that do not entail a traditional industrial R&D process, and in many instances even require little or no resources. Examples are manifold, such as India's frugal innovation model, the various meanings currently attributed to the term "social innovation", and the fragmentation of the definition of innovation into its product, process, marketing and organisational dimensions. A look at the Forbes list of the top innovative companies for 2014 provides a snapshot of the new understanding of innovation in the international community: while the top 15 include many pharmaceutical companies, it also includes cloud computing companies and even unexpected champions such as Hermés International and Monster beverages.[4] The top R&D investors around the world are not necessarily the leading innovators, and innovation takes place throughout the value chain, including at the business model and distribution channel levels. This is no surprise: looking at the data on labour productivity in the United States and the European Union, it strikes one immediately that one of the main determinants of the gap between the two blocs is the availability of high-level managerial skills.[5]

Second, innovation is "changing skin" at an accelerating pace. The past decade marked a sea change in the way innovation occurs in various sectors. This is even truer for the ICT sector, where the intangible nature of most product and system components makes it possible to obtain innovative products through collaborative efforts distributed throughout the globe. At least four major trends can be highlighted:

- *From single-firm to systemic to collaborative*: Today, innovation is increasingly a collaborative, collective effort, rather than the product of a single brain in an R&D lab. Forms of collaboration give rise to new conglomerates governed mostly by weak property rules or even liability rules. The typical examples are "copyleft" rules in open-source software, FRAND licensing agreements in patent pools and royalty-free cross-licensing agreements.[6]

- *From proprietary to modular to granular*: The modularity of products has been on the rise in recent decades, as testified by the pioneering work of Langlois.[7] Increasingly, modularity determines the need for collaboration between producers of complementary goods and services, and intellectual property is being (or should be) redesigned to facilitate these forms of cooperation.

- *From supply-led innovation to co-innovation to user innovation*: The original paradigm of "technology push, demand pull" in innovation belongs to the History Channel today. Co-innovation is becoming more

4 See http://www.forbes.com/fdc/welcome_mjx.shtml.

5 See e.g. N. Bloom, J. van Reenen: Why do management practices differ across firms and countries?, in: Journal of Economic Perspectives, Vol. 24, No. 1, 2010, pp. 203-224; and W. Steffen, J. Stephan: The role of human capital and managerial skills in explaining productivity gaps between East and West, in: Eastern European Economics, Vol. 46, No. 6, 2008, pp. 5-24.

6 FRAND stands for Fair, Reasonable and Non-Discriminatory. See R.P. Merges: Contracting into liability rules: intellectual property rights and collective rights organizations, in: California Law Review, Vol. 84, No. 5, 1996, pp. 1293-1393. See also D. Geradin: Standardization and technological innovation: some reflections on ex-ante licensing, FRAND, and the proper means to reward innovators, TILEC Discussion Paper No. 2006-017, 2006.

7 R.N. Langlois: External economies and economic progress: the case of the microcomputer industry, in: Business History Review, Vol. 66, No. 1, 1992, pp. 1-50. See also H. Chesbrough: Towards a dynamics of modularity: a cyclical model of technical advance, in: A. Prencipe, M. Hobday (eds.): The business of systems integration, Oxford University Press, Oxford 2004, pp. 174-198; and H. Chesbrough: Open Innovation, Free Press, New York 2003.

widespread, especially in the IT world, but also in other technology-intensive sectors such as pharmaceuticals and biotech. In emerging economic sectors, especially in the digital environment, co-innovation is being replaced or complemented by user innovation, in which users take the lead in developing new solutions that match their industry needs.

- *From closed to semi-open to (almost fully) open*: As collaboration and granularity become more widespread, product architectures also become less proprietary and are gradually replaced by semi-open and fully open models of production. For example, in modern broadband communications platforms such as those found on our smartphones and personal computers, proprietary models such as those adopted by Apple in the 1980s have been supplanted by semi-open models such as the one coordinated by Microsoft, which tried to maximise two-sided market effects by stimulating the widespread development of Windows-compatible applications.[8]

Third, innovation is an ecosystem, and as such it requires the simultaneous existence of several actors, each with a different role to play. In academic literature, the concept of a National Innovation System emerged in the 1980s and is normally referred to as "the set of public and private actors involved in the exploitation and commercialisation of new knowledge originating from the science and technology base and the interactions in between them".[9] This concept has been operationalised by several academics, including, among others, Porter and Stern and Archibugi et al.,[10] who develop indexes of national innovative capacity that rely heavily on the specific role played by each of the main actors that shape innovation patterns and success in a given country. These actors include large businesses and SMEs, university and research institutes, venture capitalists and business angels, and government. All the key players and elements of an innovation ecosystem have to be in place for a country to be able to create innovation in support of growth and well-being. This means that investing in R&D is not going to be a sufficient strategy unless large and small companies are able to develop an effective symbiotic relationship, fed by the university system, supported by public or private funding sources, demanded by a sufficiently large market, and facilitated by an innovation-oriented government.

In this latter respect, the science of government has changed along with the changing nature of innovation. While important academic contributions recognise the importance of the state in driving innovation, such a role cannot (and should not) focus solely on the provision of funding.[11] Rather, the state increasingly needs to act as a catalyst, able to realise the convergence and synergies between all necessary actors in the innovation ecosystem, while at the same time ensuring that innovative activity is encouraged, not stifled, by existing rules; that information can flow effectively in the marketplace, enabling the matching of supply and demand; that innovators have world-class infrastructure available to them, from connectivity to logistics; and that universities teach the right skills to their students and provide lifelong learning opportunities to both the employed and the unemployed throughout their lives.

This description of the changing role of the state becomes even truer if one considers that by the end of the decade, we will witness important shifts in the way production is organised and in the way innovation takes place. Already now, the advent of cloud computing is enormously reducing the cost of market entry for small companies, while also providing SMEs with attractive platforms for innovation at little or no cost. Competition among platform operators such as Amazon, Salesforce, Google, Microsoft and many others is leading to the emergence of competing, semi-open architectures, each of which aims at maximising the number of applications available to their customers, and this in turn lowers barriers to entry for small, creative companies wishing to find space in the cloud. A year ago, an industry study already claimed that the European app economy accounted for 1.8 million jobs and blossoming sales volumes – without any need for EU funding.[12]

Second, the emergence of the Internet of Things is paving the way for a number of innovative applications in a growing number of fields, again with limited need for

8 Since then, more open models (partly) based on open-source software have become more important. However, especially in the smartphone and mobile broadband sector, the business models that prevail (e.g. Android and Apple's iOS) are still semi-open and not fully open. This is due to two main reasons: the need to preserve control of the value chain and the need to reap revenues through the creation of modern platforms. As a matter of fact, a fully open and interoperable model in most cases does not guarantee any revenues to its creator, as it basically belongs to the public domain.

9 See the definition given by the European Commission, available at: http://ec.europa.eu/enterprise/glossary/national-innovation-system_en.htm.

10 M.E. Porter, S. Stern: National innovative capacity, in: World Economic Forum, The Global Competitiveness Report 2001-2002, Oxford University Press, New York 2002, pp. 102-119; and D. Archibugi, M. Denni, A. Filippetti: The Global Innovation Scoreboard 2008: the dynamics of the innovative performances of countries, 2009.

11 See M. Mazzucato: The Entrepreneurial State, Demos, London 2011.

12 See D. Card, M. Mulligan: Sizing the EU app economy, Gigaom Research, February 2014.

high R&D investment at the outset. Innovation is likely to occur at a breathtaking pace with respect to the fourth industrial revolution or "industry 4.0", which entails the use of cyber-physical products and services in support of cheaper, optimised industrial production of increasingly personalised products. Countries that are betting on this development, like Germany and the US, are already seeing the emergence of new start-ups that develop customised applications for specific phases of the virtualised production plants that are key to the development of industry 4.0. What these start-ups need, more than seed money, are a limited number of emerging platforms on which to test their ideas. Moreover, the development of technologies such as 3D printing is revolutionising the way in which firms test their products and develop them before deciding to build them. Many commentators have argued that this and similar technological solutions are leading to the end of the economies of scale in production and to a new era of mass customisation in products and services.

Finally, the direction of innovation is likely to change, with companies blurring the boundaries between sectors. The recent investment made by Google X Life Sciences for the development of nanoparticles able to locate cancer cells is just one of many examples of companies that exploit their pivotal role in the new economy to extend their reach into other sectors and experiment with innovative solutions. Amazon's investment in civil drones is another example. The more companies can reach end users and collect large amounts of data, the easier it becomes for them to create bridges between sectors. And the bigger they become, the more they need creative and innovative solutions to integrate within their giant platforms. This is where most of the innovation is likely to take place in the years to come.

Faced with such developments, what should a government do to stimulate innovation? Public institutions can certainly play a crucial role in creating the right conditions for the acceleration of technological solutions to address emerging societal challenges, but they need to focus their efforts on addressing large-scale societal challenges that market forces are unlikely to tackle by themselves, on creating a fertile environment for entrepreneurship by tailoring regulation to the needs of innovation, and on ensuring that private sector innovation does not occur at the expenses of social welfare in the medium to long term.

Horizon 2020: from hope to demise?

Against this background, the past years of innovation policy – most notably the launch of Horizon 2020 – have brought some beacons of hope. These are not exclusively related to the amount of money allocated to research and innovation in the EU budget, but instead are mostly due to the emphasis placed on the governance of innovation rather than on the selection of projects based on pre-determined criteria. In this respect, the three pillars of Horizon 2020 – excellent science, industrial leadership and societal challenges – appear much more in line with the needs of potential innovators and entrepreneurs than past projects like the 7th Framework Programme for Research and the Competitiveness and Innovation Programme for SMEs.

In addition, and most importantly, the work of the European Institute of Innovation and Technology so far has led to a new way of approaching the governance of innovation through so-called Knowledge and Innovation Communities (KICs). Apart from the promising results obtained by the first three KICs (Climate-KIC, EIT ICT Labs and KIC InnoEnergy), new KICs focused on innovation for healthy living and active ageing, raw materials, added value manufacturing and food4future seem to have the potential to stimulate innovation in their respective domains. New programmes on access to finance carry the promise of reducing red tape for SMEs and, at the same time, bring the European Investment Fund closer to potential innovators through enhanced partnerships with local authorities or financial institutions. Further good news includes the earmarking of more structural funds for research and innovation in the 2014-2020 financial framework and the new Framework for State aid for Research & Development & Innovation (R&D&I), which is expected to enable public support to address market failures that may hamper the financing of R&D&I in Europe.

So far, so good. However, the first steps of the Juncker Commission seem to have marked a change of direction, with innovation policy apparently losing traction compared to the prominence it had been given, at least formally, by the second Barroso Commission. Compared to the (only partly successful) past attempts to centralise and coordinate initiatives related to innovation, the Juncker Commission seems to believe in a greater fragmentation of innovation policy instruments, which now fall under a widely diverse set of DGs and agencies. Suffice it to say that the Joint Research Centre has been moved under the responsibility of DG Education. Moreover, the fact that the mandate letter sent to Carlos Moedas, the new Commissioner for Science, Research and Innovation, does not mention basic science as a priority has raised many eyebrows. And even the recent €315bn European Fund for Strategic Investments announced by Juncker does not reserve a clear or prominent role for R&D, despite the fact that it will be drawing funds for at least €2.8 billion from Horizon 2020.[13]

Is this necessarily bad news for EU innovation policy? No, although important caveats apply. The main reason why the new course is not necessarily a step backwards is that the EFSI seems likely to focus mostly on pan-European infrastructure deployment. This has attracted criticism but is fully in line with the role of government in emerging innovation ecosystems: serving as the facilitator, in charge of creating the most viable conditions for innovative activity to take place. After all, the past years have not shown great value for the public spending at the EU level dedicated to research. Investments in infrastructure could end up having a more significant impact on entrepreneurship and innovation than an upfront allocation of funds to difficult-to-locate innovative activities.

To be sure, this would only happen under very restrictive conditions. First, the quality of the projects that will be selected for funding through the EFSI will be essential, and the procedures that will be followed for project selection are not known in detail as of now. If the European Investment Bank ends up handling the selection of projects, this risks passing on to the EFSI project the ineffectiveness of the Bank in selecting valuable beneficiaries.

Second, Horizon 2020 can be reformed in several respects to ensure even greater value for money. Among the most advisable changes would be the implementation of a policy to avoid fragmentation among platforms dedicated to the same (or similar) societal challenges, such as European Innovation Partnerships, Joint Technology Initiatives and Knowledge and Innovation Communities. In addition, initiatives on advanced manufacturing should be prioritised even more so than is already the case. While the planned KIC in this area is not anticipated to be ready before 2016, the German "Industry 4.0" initiative and the US advanced manufacturing initiative are already up and running.

Third, a thorough reform of the EU education system is absolutely essential. For example, despite the 26 million unemployed European citizens, there are an estimated 900,000 vacant posts in the ICT industry, mostly in cloud computing, and the gap between supply and demand reportedly widens every month.

13 See R. Veugelers: The Achilles' heel of Juncker's Investment Plan, Bruegel, 8 December 2014.

Fourth, the upcoming review of the Europe 2020 strategy will be a unique opportunity to replace the current indicator, which focuses on spending three per cent of GDP on R&D, with a more meaningful, outcome-based indicator of innovation. It also offers the chance to merge or further coordinate the four key flagship initiatives that are most relevant to innovation (Innovation Union, Industrial Policy for the Globalization Age, New Skills for New Jobs, Digital Agenda) to concentrate direct action on a few pressing societal challenges, while simultaneously utilising indirect actions to create a fertile innovation ecosystem. The Latvian Presidency will have to finalise the proposed review in March 2015, hopefully with a strong emphasis on the innovation policy angle.[14]

Fifth, infrastructure policy (inside and outside the EFSI) is key to the future of innovation, especially – but not exclusively – concerning internet connectivity. This is why renewed efforts have to be devoted to the deployment of ultra-fast broadband infrastructure in all EU member states. Insufficient connectivity, in the era of virtualised production and 3D printing, can exclude a country from the most thriving global value chains.

Finally, there is a strong need to recognise that innovation is affected by many other EU policies that are not part of the innovation policy domain. These include regulatory reform, red tape reduction, and most importantly internal market policies such as competition law, public procurement legislation, standardisation and sector-specific regulation. As observed inter alia by Larouche and Schinkel, it seems that competition policy should be handled by the European Commission in a way that is innovation-compatible and should therefore place a greater emphasis on long-term dynamic efficiency than on the short-term static efficiency effects of market outcomes.[15]

Only by working in all these directions will the new European Commission be able to boost innovation and entrepreneurship by developing a mix of policies that do not specifically mention any of the two words. Only then could the choice of a rather "thin" portfolio for Moedas and fewer ad hoc institutions for innovation eventually pay off. If this happens, it would put Europe back in a situation in which innovation is not a policy but rather an outcome.

14 A. Renda: The Review of the Europe 2020 Strategy. From Austerity to Prosperity?, CEPS Policy Brief No. 322, 27 October 2014.

15 P. Larouche, M.P. Schinkel: Continental Drift in the Treatment of Dominant Firms: Article 102 TFEU in Contrast to § 2 Sherman Act, TILEC Discussion Paper No. 2013-020, 2013.

Carlos Montalvo and Jos Leijten

Is the Response to the Climate Change and Energy Challenge a Model for the Societal Challenges Approach to Innovation?

One of the major differences between Horizon 2020 and the preceding Framework Programmes is a rather explicit portfolio approach. Horizon 2020 has three distinct and complementary funding boxes: research excellence, industrial leadership and societal challenges. The creation of an excellent European research base has always been one of the major Framework Programme goals. Apart from a considerable increase in funding under Horizon 2020, "industrial leadership" also brings another major new element which could be summarised as "funding for the removal of market barriers". So far Framework Programmes mainly focused on the development of new technologies and applications in collaboration between industry and public research. Horizon 2020 also explicitly addresses barriers to bringing these new technologies and applications to market: funding is available for setting up pilot production facilities (in particular in fields of high risk and high costs) and for overcoming other barriers associated with the so-called commercialisation "valley of death".[1] This approach to industrial leadership significantly expands the role of public funding within the traditional linear model – from fundamental science discoveries to technology development to marketable products.

But an even deeper change can be found in the third box of Horizon 2020, societal challenges. The central goal of this approach is to foster innovation to work on solutions to (grand) societal challenges and thus also to create drivers and opportunities for economic growth (new business activities). In other words, the starting point is not scientific discovery but important societal needs. According to the Horizon 2020 website, these needs will guide a process of bringing together "resources and knowledge across different fields, technologies and disciplines, including social sciences and the humanities", and it will not only include research activities but also "innovation related activities such as piloting, demonstration, test-beds, and support for public procurement and market uptake".[2] The focus is on the following challenges:

- health, demographic change and wellbeing
- food security, sustainable agriculture and forestry, marine and maritime and inland water research, and the bio-economy
- secure, clean and efficient energy
- smart, green and integrated transport
- climate action, environment, resource efficiency and raw materials
- Europe in a changing world – inclusive, innovative and reflective societies
- secure societies – protecting the freedom and security of Europe and its citizens.

From these titles, it can be gathered that implementation of the challenge-oriented research and innovation programmes under Horizon 2020 (still) shows a wide diversity of poorly targeted and weakly coordinated actions. The goals with regard to economic growth and job creation remain largely at the level of ambitions. But these ambitions might mark the starting point of the development of a completely new approach to innovation in which societal demand is taken as the prime driving force.

In a way, grand challenges or major societal challenges have always been important as drivers for innovation, economic growth, and solving social and environmental problems.[3] In particular, they have been drivers for public investments in science, technology and related infrastructures. What is new is that thinking in terms of grand challenges as shared visions or goals which guide the actions of a broad (international) stakeholders' community is being put forward as a means to bring Europe to the forefront of R&D and innovation. This is a change in policy thinking after a period of more than 20 years in which science, technology and innovation policies were dominated by a preference for generic measures and a relative reluctance on the side of politics to identify and

1 This is extensively discussed in European Commission: High Level Expert Group on Key Enabling Technologies, Final Report, June 2011.

2 See http://ec.europa.eu/programmes/horizon2020/en/h2020-section/societal-challenges.

3 It should also be noted that demand-driven innovation is not new. There is extensive literature on the topic and many governments, including the European Commission, have experimented with smaller programmes for demand-driven research and innovation.

implement strong guiding principles or make strong thematic choices.

In this note, we will explore the opportunities and potential impacts of the societal challenges approach. In particular, we will look at the experiences in the field of climate change and energy – which can be seen as the oldest politically recognised challenge – as an innovation driver and explore whether these experiences provide a model for other challenges. But first we will provide more background on the grand challenges approach and how it has now become an essential part of Horizon 2020.

Horizon 2020: the introduction and conceptualisation of the grand challenges approach

After a decade of increasing productivity accompanied by decreasing employment rates, sluggish demand and slow economic growth, Europe is now in the middle of a transition stage. The Lisbon Strategy had several flagship targets (notably growth, employment, productivity, innovation and research, education and training, and social and environmental policies) that were not met during its implementation period. For this failure, the European Commission was strongly criticised.[4] The midterm and final review of the Lisbon Strategy period demanded a different rationale with a more ambitious and inclusive strategy that would allow the pursuit of previous targets while allowing for a different emphasis. Such a new emphasis should provide some political slack and higher legitimacy for new policies. Exploratory and evaluation studies on the rationale of the societal challenges for innovation policy making date back to 2006.[5] After 2010, with the advent of the new European 2020 Strategy, the notion that Europe should focus its efforts on tackling grand challenges became mainstream.[6] What is new in the approach taken in Europe is the commitment (or need) to create a shared vision or goals to guide a broad international community as a means to bring Europe to the forefront of R&D and innovation.[7]

It is expected that the way politics, business and people in general handle challenges such as climate change or ageing populations will strongly affect the economy and society in the coming decades, both in Europe and worldwide. But the broad societal risks and problems which the challenges represent also provide opportunities for new (business) activities, goods and services and for moving towards a smart, sustainable and inclusive economy.

In Europe the challenges approach was announced in Europe 2020,[8] which built on earlier thinking about "grand challenges", such as the views expressed in a report by the Rationales for the European Research Area (ERA) Expert Group.[9] This expert group addressed a problem which was identified in the 2007 ERA green paper:

> National and regional research funding (programmes, infrastructures, core funding of research institutions) remains largely uncoordinated. This leads to dispersion of resources, excessive duplication, unrealised benefits from potential spillovers, and failure to play the global role that Europe's R&D capability would otherwise allow, notably in addressing major global challenges.[10]

Grand challenges involve a combination of major public and private interests, are seen as key for realising future economic growth, and are concerned with important human, social and/or environmental problems. Grand challenges are not to be defined, assessed or solved by any single scientific or technological discipline or within one specific sectoral policy framework. Societies are facing complex, interlinked, global and local challenges. It is evident that we need new policies, new governance models, new innovation solutions and strategies, and new investment models for challenges like healthy ageing and climate change. But the necessary holistic approach

4 European Parliament: The Lisbon Strategy 2000-2010: An analysis and evaluation of the methods used and results achieved, IP/A/EMPL/ST/2008-07, Brussels 2010; J. Leijten, M. Butter, J. Kohl, M. Leis, D. Gehrt: Investing in research and innovation for Grand Challenges, Report to the European Commission, JIIP, Brussels 2012; C.L. McGrath, V. Horvath, B. Baruch, S. Gunashekar, H. Lu, S. Culbertson, P. Pankowoska, J. Chataway: The international dimension of research and innovation cooperation addressing the grand challenges in the global context: Final Policy Brief, RAND Europe, Brussels 2014.

5 C. Montalvo, P. Tang, J. Mollas-Gallart, M. Vivarelli, O. Marsilli, J. Hoogendorn, M. Butter, G. Jansen, A. Braun (eds.): Driving Factors and Challenges for EU Industry and the Role of R&D and Innovation, ETEPS AISBL, Brussels 2006.

6 C. Cagnin, E. Amanatidou, M. Keenan: Orienting European innovation systems towards grand challenges and the roles that FTA can play, in: Science and Public Policy, Vol. 39, No. 2, 2012, pp. 140-152.

7 J. Leijten et al., op. cit.

8 European Commission: EUROPE 2020: a Strategy for Smart, Sustainable and Inclusive Growth, Communication from the Commission, COM(2010) 2020, Brussels 2010.

9 European Commission: Challenging Europe's Research: Rationales for the European Research Area (ERA), Report of the ERA Expert Group, 2008, p. 36: "To capture the imagination of the research community and its stakeholders we are proposing that the next stages of ERA are rolled out through a series of actions addressing the Grand Challenges facing Europe. These challenges are both economic and more broadly concerned with social and environmental goals. This approach can shift perceptions as well as focus from deficit to opportunity."

10 European Commision: The European Research Area: New Perspectives, Green Paper, COM(2007) 161, Brussels 2007, pp. 6-7.

also includes the need for highly specialised knowledge and highly specific technological and organisational solutions. Grand challenges involve many different stakeholders, and they are multidimensional, transdisciplinary and systemic; furthermore, they require new ways of thinking which go beyond traditional frameworks and disciplines, leading to a rethinking of research and innovation policy.

The most common use of the concept of "grand challenge" is in the meaning of scientific or technological challenges. This type of challenge approach may gain in popularity again in Europe, because there appears to be a growing interest in "prize mechanisms" to stimulate a demand-driven search for solutions of societal problems.[11] This approach lends itself particularly well to soliciting technological solutions.

Although there are clear linkages with such engineering challenges, it is obvious that Europe is aiming for a broader approach to societal challenges. The 2009 Lund Declaration,[12] building on the recommendations of the ERA expert group, proposes the following characteristics as important:

- move beyond rigid thematic approaches, focus on societal challenges
- approach to include global public and private stakeholders
- EU has process ownership, but it includes alignment of national initiatives.

Reviewing the different policy documents addressing the issue, we can distil the following characteristics as important elements of a European approach to grand challenges:

- the longer-term sustainability of a society or country is at stake
- mission-oriented, systemic solutions that attempt to solve societal problems
- multi-level, multi-stakeholder participation
- focus on alignment and coordination of strategies
- linking economic growth to societal benefits
- combining research, technology and innovation in a multi-disciplinary way.

In a more operational way, this new mission-led approach works along the following principles:[13]

- combining societal needs and technological inputs to generate solutions for these needs and challenges
- decentralised process of identifying and selecting priorities
- involvement of multiple actors
- quick and broad diffusion of research results
- acknowledgement of the importance of incremental innovations rather than of radical innovations.

It is clear from the above that the European approach to grand challenges starts from the recognition of the complexity of the problems at hand and the need to include broad stakeholder perspectives. An important element is the fact that the challenges are mostly defined as "global" and thus require a certain amount of international coordination. There are several efforts to tackle challenges globally by governmental (UN, OECD[14]) and non-governmental (foundations) bodies, by global region-based collaboration (East Asia) and by bilateral collaboration (e.g. Australia-India). In the case of Europe, there is ambiguity about the way intra-European coordination should take place: should it be based on voluntary actions by the member states with support from the Commission (Joint Programming Initiatives) or is stronger coordination at the European level needed?

There are major differences in how a challenge is addressed in research and even more so in innovation. The "climate change and energy" challenge falls within a tradition of many years of debate and policymaking on environmental issues. Other challenges are less explicitly recognised, partly because they are of a more recent nature, less "internationalised" (healthy ageing) or less broadly recognised in society (security). Apparently it takes time before a challenge is really taken up as a broad societal challenge. The following section very briefly discusses how this happened in the climate change/energy field.

Climate change and energy as a challenge

The issue of climate change in relation to energy provides us with a strong model to analyse the likely pattern of development of a societal challenge and how it relates

11 See also J. Leijten, H. Roseboom, R. Hofer: More Frontier Research for Europe, A Venture Approach for Funding High Risk – High Gain Research, Report to European Commission, JIIP, Brussels 2010.

12 Swedish EU Presidency: Lund Declaration: Europe Must Focus on the Grand Challenges of our Time, 8 July 2009. It is important to recall that the Lund Declaration also includes a set of broader framework conditions which need to be fulfilled for a successful grand challenges approach.

13 H. Gassler, W. Polt, C. Rammer: Priority setting in technology policy: historical developments and recent trends, in: C. Nauwelaers, R. Wintjes: Innovation Policy in Europe: Measurement and Strategy, Cheltenham 2008, pp. 203-224, here pp. 214ff.

14 Norwegian Ministry of Education and Research: Governance of international cooperation on science, technology and innovation to address global challenges, Discussion Paper submitted to the Oslo Workshop on International Co-operation in Science, Technology and Innovation to Address Global Challenges, 18-20 May 2011.

to networks of innovation and global production. Such a model might be applicable to other challenges. The analysis leads to a stylised description of how the structuration process of the challenge develops from identification and legitimisation to the creation and expansion of a new market and how this is mediated by technical change and innovation. The following sequence of events is not necessarily linear, and there are some recursive loops included:

a) definition of the societal challenge (the issue)

b) development and accumulation of a critical mass among different types of actors that recognise the issue as important and are willing to generate visions and contribute to the solution

c) appearance of lobbying groups (pro and contra) and increased public debate

d) emergence of institutions advocating, hosting and proposing approaches to address the issue

e) development of technical and managerial approaches to address the issue

f) adoption of the issue in the policy agenda by governments and multilateral organisations

g) investment flows to develop and test solutions while patenting and intellectual property rights are settled

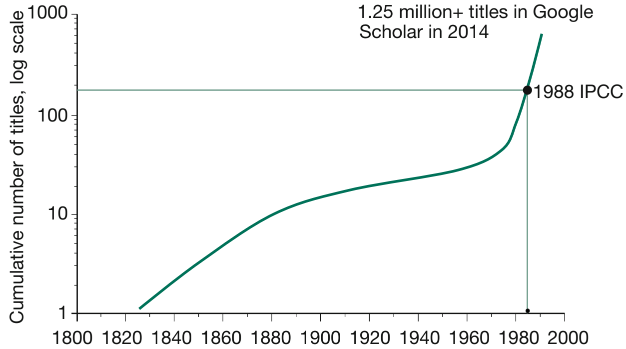
h) early adoption sprouts niche markets supported by policy instruments (e.g. taxes and subsidies), as regulation and standards start to consolidate markets

i) investments for production up-scaling often backed by sectoral policy and regulation as wider diffusion takes place

j) mass markets growth; competition and distribution of production locations become issues for industrial policy.

Climate change could well be one of the first visible and working models of a (global) societal challenge and how the innovations it drives are restructuring global production and consumption in energy markets. Some of the elements of such a model are outlined below. Figure 1 shows the growth of the number of publications on climate change. In many publications, most of the attention so far has been given to energy sources and usage, but other publications are also linking energy sources and usage to developments in other sectors such as transport, lighting, construction, cement and agriculture.

Figure 1
Publications on climate change



Source: Own elaboration based on G. Stanhill: The growth of climate change science: A scientometric study, in: Climatic Change, Vol. 48, No. 2-3, 2001, pp. 515-524.

Figure 1 shows how two important developments came together: a very rapid increase in the number of publications on climate change and the building of a consensus that climate change is real and that the main cause is the accumulation of gases in the atmosphere, especially CO_2. This should be seen as the start of a common understanding of the challenge. Since 1977 the number of published papers has doubled every 11 years, and the trend continues to date, as confirmed by recent searches in Google Scholar.[15] To come to a shared understanding of the challenge and the causal mechanisms required an enormous amount of fundamental research. Following a decade that saw a logarithmic increase of three orders of magnitude in the number of publications on climate change, the United Nations Intergovernmental Panel on Climate Change was created in 1988. The creation of such an institution required massive debate in multilateral organisations.

The road to the first agreement on limiting global emissions took about nine years. In 1997 the first agreement on the Kyoto Protocol was signed by many nations. The signature of the Protocol and later the negotiations on the targets legitimated the need for actions on a global scale to mitigate the potential effects of climate change. Although the debate continued, the development of technology solutions reflected in patenting activity in renewable energy technology increased significantly after the agreements on the Kyoto targets to limit the CO_2 present in the atmosphere.

15 G. Stanhill: The growth of climate change science: A scientometric study, in: Climatic Change, Vol. 48, No. 2-3, 2001, pp. 515-524.

Although there is still scepticism concerning climate change projections,[16] the need for action to reduce CO_2 emissions has entered in the discourse and policy agendas and thus gained legitimacy for the "urgent" need for action. Similarly, markets have reacted to the challenge and economic opportunities this brings for (global) business. With a time lag of just a few years following the increase of the patenting rate, the level of reported investment in the production and installation of renewable energy technologies has also significantly increased.[17]

The business interest and economic impact are becoming clear from the large increase of capital flowing into energy-related innovations. For example, Ethical Markets Media reported $2.4 trillion of cumulative worldwide investment in eco-innovation during the period 2007-2011,[18] while the expected cumulative investment by the year 2020 was estimated at $10 trillion.[19] Innovations that address the climate challenge (e.g. in energy, mobility, water, etc.) are now creating new global markets, allowing smart specialisation in some regions and giving governments politically acceptable long-term horizons for policy action.

Seen from the perspective of innovation, the process of tackling the climate change challenge reveals at least three important steps (a simplified version of the previous list):

- reaching a shared understanding of the need for action, which requires a lot of fundamental research and connecting politics with science, and which in the meantime leads to a restructuring of the research field (new institutes, new forms of collaboration);
- creating technological solutions, which may include unconventional approaches such as competitor companies sharing their patents in order to foster the development of solutions;
- investment and market development, including the rise of new companies, shaping the necessary regulatory environment and new institutions.

Discussion

Before going into more detail about the role of Horizon 2020, two questions need to be posed. The first question is whether the climate change/energy challenge indeed provides a model for other challenges, such as healthy ageing, water, food or security. Climate change and energy is a societal challenge whose globally interdependent nature was more or less accepted from the beginning of discussions and research, even when most of its implications are unevenly felt across countries, regions and localities. Other challenges like health, water, food and security also have such global interdependencies, but so far national and regional political agendas have tended to dominate.

The establishment of global research and innovation networks in science and technology can help to build an arena which links the local implications and potential solutions to the global dynamics. It can help to create an environment in which potential conflicts between regions and nations can be mediated. The strong and long-standing collaborative dynamics of global innovation networks related to energy, especially in the area of R&D, might have some lessons to offer to other policy areas. In the field of healthy ageing, we see broad international research networks appearing. The globally operating pharmaceutical companies might in principle play a role in extending such collaborations further into the field of innovation. Other challenges which have belonged to the realm of national and regional/local governments – sometimes for hundreds of years – will require an even stronger internationally collaborative research and innovation effort in order to turn them into global drivers for global solutions. Such a structuration process will not be easy. The implementation of the shared vision to face the grand challenges requires the capacity to create convergence, and it should enable the interoperation of complex multi-actor networks. It also requires a logic of systems integration that is often at odds with the decentralised decision making and management style presently dominant in national or sectoral approaches. Specifically in the case of Europe, the present political decentralisation tendencies may raise the barriers for an effective challenge-driven approach.

The second question is if and how the challenge-driven approach helps Europe to make the transition to the next phase in global innovation and production systems. The international economic context has moved to a new,

16 L. Withmarsh: Scepticism and uncertainty about climate change: Dimensions, determinants and change over time, in: Global Environmental Change, Vol. 21, No. 2, 2011, pp. 690-700; W. Poortinga, A. Spence, L. Whitmarsh, S. Capstick, N.F. Pidgeon: Uncertain climate: An investigation into public scepticism about anthropogenic climate change, in: Global Environmental Change, Vol. 21, No. 3, 2011, pp. 1015-1024.

17 N. Johnstone, I. Haščič, D. Popp: Renewable energy policies and technological innovation: Evidence based on patent counts, in: Environmental and Resource Economics, Vol. 45, No. 1, 2010, pp. 133-155.

18 This is broader than renewable energy but likely to show similar patterns.

19 C. Montalvo, F. Diaz-Lopez, F. Brandes: Potential for eco-innovation in nine sectors of the European economy, European Commission, DG Enterprise and Industry, Brussels 2011.

multipolar era in which the rules of the competitive game are being reset. Leading economies and newcomers in global markets (e.g. India, China, South Korea, Taiwan, Singapore, etc.) have mastered not only the know-how for cost-driven competition,[20] but they also have become innovative in both traditional and in selected high-tech sectors.[21] Global competition and new technologies drive the cores of innovation and production networks closer to consumption and closer to important markets.[22] The transition has to take place when governments in several advanced economies, and certainly in Europe, can no longer rely on a broad electorate's confidence and on the legitimacy of their policy agendas to ensure the societal welfare, employment and growth. But the needs-driven notion of societal challenges offers the opportunity to articulate a structure of innovation and production in a new combination of global networking and local action. Such a new competitive landscape not only requires a significant restructuring of the global patterns of production, but the production of knowledge and innovation driven by societal challenges may help to build the arena in which actions can be taken. Thus, innovation will play an important role as a means for restructuring and for legitimation of new global production networks and markets.

Horizon 2020 and beyond

For Europe this transition starts with the implementation of Horizon 2020. The largest portion of the Horizon 2020 budget, almost 40 per cent (i.e. €31 billion) is dedicated to exploring and creating approaches and technologies with which to tackle the grand challenges.[23] From a political economy perspective, the Europe 2020 strategy, underpinned by the notion of societal challenges, aims to:

- develop and mature new competences, skills and technologies, as defined by specific programmes contributing to the solution of a societal challenge;

- set up new institutions, standards and regulations supporting European industrial and market leadership;

- create global consensus and shared visions that underpin the creation of new markets.

The first point of this agenda and vision is reflected in programmes that together form Horizon 2020, and this includes a strong role for enabling competencies such as those developed under, for example, Factories of the Future, Future and Emerging Technologies, or the excellence-driven funding of the European Research Council. Such programmes directly or indirectly aim to tackle societal challenges, to underpin the building of competitive roles in global innovation networks and to set the grounds for global industrial leadership. The other two points are the topic of much broader policy actions. Closer to the market, the process will require the creation of new institutions that apply regulations and standards across industries and nations. Those firms or countries which manage to set the new standards and adapt or create their institutions according to the new business models required by the new rationale of bringing solutions to the societal challenges are likely to be best positioned in the restructured regional or global value networks.

The period 2010-2020 can be considered a transitional phase in which the foundations for the period 2020-2050 are to be set. Such foundations include facing societal challenges and the new global geopolitical and competitive landscape. Developments in tackling the climate change and energy challenge and its structuration are now continuing at an increasing pace (e.g. setting standards, technological competition, varied national support, new collaboration models, etc.). European companies play a major role in this process. Competition is moving on from present markets to the creation of future ones. The precompetitive activities are not only focusing on R&D and innovation but also on norms and institution-building.

In this sense, the climate change and energy model seems a promising approach, as it provides a tractable example of the dynamics of the massive alignment of vision and multilateral agendas akin to global issues. The potential economic and social impact, as already shown by the rise of the energy markets, is large. Learning the lessons offered by this model and its application in other areas of grand challenges may yield similar outcomes. But at the same time, it should be noted that one cannot expect quick results. Solutions will have to be moderated in a lengthy structuration process. The period 2010-2020 should be seen a preparatory period where a broad scope of pre-competitive activity is taking place. Following the timing and logic offered by the climate change and energy model and the Kondratiev waves of economic development, we could expect that global markets and economic expansion are to take off well beyond 2020.

20 F.J. Contractor, V. Kumar, S.K. Kundu, T. Pedersen: Reconceptualizing the Firm in a World of Outsourcing and Offshoring: The Organizational and Geographical Relocation of High-Value Company Functions, in: Journal of Management Studies, Vol. 47, No. 8, 2010, pp. 1417-1433.

21 F. Montobbio, E. Bacchiocchi, L. Cusmano, F. Malerba, F. Puzone, D. Fornahl, H. Gruppy, J. Stohr, T. Schubert, C.A. Tran: National Specialisation and Innovation Performance, Final Report, Europe INNOVA Sectoral Innovation Watch, European Commission, Directorate General Enterprise and Industry, Brussels 2010.

22 See for an extensive discussion of the recent trends 6CP: Can policy follow the dynamics of global innovation platforms?, Delft, forthcoming.

23 D.M. Judkiewicz: 2014 and beyond, R&D Trend Forecast in Europe: Horizon 2020, EIRMA, 2014.