EUROPEAN COMMISSION

European Research Area

# Knowledge for Growth : Prospects for science, technology and innovation

European Research Area

REPORT

Knowledge for Growth : Prospects for science, technology and innovation

## Interested in European research?

***Research*eu*** is our monthly magazine keeping you in touch with main developments (results, programmes, events, etc.). It is available in English, French, German and Spanish. A free sample copy or free subscription can be obtained from:

European Commission
Directorate-General for Research
Communication Unit
B-1049 Brussels, Belgium
Fax (32-2) 29-58220
E-mail: research-eu@ec.europa.eu
Internet: http://ec.europa.eu/research/research-eu

**EUROPEAN COMMISSION**

Directorate-General for Research
Directorate C – European Research Area: Knowledge-based economy
Unit C.3 – Economic analysis and monitoring of national research policies and the Lisbon Strategy
Contact: Werner Wobbe
Address: 8, Square de Meeûs, B-1049 Bruxelles
Office SDME 09/88
Tel. +32 2 29 50879
Fax +32 2 29 67026
E-mail: werner.wobbe@ec.europa.eu

EUROPEAN COMMISSION

# Knowledge for Growth
## Prospects for science, technology and innovation

*Selected papers from Research Commissioner Janez Potočnik's Expert Group*

November 2009

Directorate-General for Research
2009 7th Framework Programme - Capacities EUR 24047 EN

**LEGAL NOTICE**

Neither the European Commission nor any person acting on behalf of the Commission is responsible for the use which might be made of the following information.

The views expressed in this publication are the sole responsibility of the author and do not necessarily reflect the views of the European Commission.

A great deal of additional information on the European Union is available on the Internet. It can be accessed through the Europa server (http://europa.eu).

Cataloguing data can be found at the end of this publication.

Luxembourg: Publications Office of the European Union, 2009

ISBN 978-92-79-13155-4
ISSN 1018-5593
doi: 10.2777/47564



*Printed in Luxembourg*

PRINTED ON RECYCLED PAPER

# *Table of contents*

## Foreword by Commissioner Janez Potočnik

The challenges of the financial and economic crisis, climate change, energy and food security and the H1N1 pandemic have made us acutely aware of two things: how interconnected and interdependent our world has become; and how important it is to find sustainable solutions for them.

Knowledge is central; both for a deeper understanding of these challenges and, through research and innovation, for finding the best solutions, which not only help us deal with the problems, but also give us an edge in our globally competitive world.

In thinking about research and innovation, both central parts of our Lisbon strategy, we should consider how we integrate our actions and policies on research and technology better. And, in drawing together all these cooperative strands, we must focus on the following areas and issues:

- Creating a single market for knowledge, allowing researchers, ideas and technologies to flow freely across Europe and which encourages better and stronger collaboration between industry and the academic world in an environment of 'open innovation'. We call this the Fifth Freedom and once fully established will create more competition and therefore support excellence in research - the basis for a competitive knowledge economy;

- Creating modern research and innovation policies, based on the principles of good governance and which are relevant to all sectors;

- Helping Member States work together better. Because even the Framework Programme is too small to address really large scale challenges alone. We are now working towards 'Joint Programming' to enable a new, more strategic and forward looking type of R&D partnership between Member States - a partnership that is based on a common vision on how to meet and beat the global and systemic crises of our time. This policy fits squarely with the idea of smart investments in research: which we hope will stimulate excellence and impact with fewer resources.

- Attracting the best brains to work in research, technology and innovation in Europe. We have to make a place where they can move around freely and where they want to make a lifelong career. With the advent of the European Research Council, we have created real competitiveness at European level for excellence in science. This can only help to increase Europe's attractiveness and strengthen its position as a global science player even further.

In 2005, I established a group of prominent economists in the field of 'Knowledge for Growth' (K4G). I called them the ‘knowledge economists’ and I wanted them to provide me with expert advice on how knowledge can contribute to sustainable growth and prosperity and to policies in support of the Lisbon Strategy goals.

I have followed the work of the K4G very closely. This has given me the opportunity to participate in sometimes very lively and controversial discussions on the very important issues raised by the group. Such as:

- On globalisation of R&D and the concept of smart specialisation in the EU, by Dominique Foray. This resulted in lively and fruitful discussions, but also, and more importantly, it helped us identify and analyse the options and the risks of such a policy, as explained by Tassos Giannitsis and Marianne Karger.

- On the EU R&D deficit, first analysed by Mary O'Sullivan. This showed that the deficit is largely the result of the European industrial structure, with European high-tech sectors, in particular ICT, being smaller and investing less in R&D than in other countries like US and Japan. The recent analysis by Brownyn Hall and Jacques Mairesse has concluded that too few EU SMEs have become big multinationals in the last few decades – showing that growth remains a major problem.

- On how "Universities and R&D organisations in the ERA" can better contribute to Europe's innovation performance. This was an issue taken up by Paul David and Stan Metcalfe.

- On the need for better governance and coordination of S&T policies in the European Research Area, as addressed by Ramon Marimon and Maria Carvalho. This issue was discussed at a conference in July 2009 in Lund, Sweden, organised under the Swedish Presidency.

- And finally, not forgetting the very lively discussions on the factors and drivers of knowledge economy convergence for the 'catching-up Member States' and possible policy options, as presented by Reinhilde Veugelers and Mojmir Mrak; as well as the importance of technology diffusion in this context as shown by Georg Licht.

The K4G group has been a major contributor to the Lisbon strategy debate and to the policies we have put in place over the last five years. In particular, the debate on specialisation in the European Research Area has opened out a crucial issue that deserves further attention.

The K4G reports have been a very valuable input to policy making and in some cases have triggered wider policy discussions; like at the Toulouse conference of the French Presidency in 2008 or more recently at the Lund conference. Its recommendations have been influential in making the idea of a European Research Area more concrete. They have also given credence to the very idea of the Lisbon strategy, by putting research and its products to work for Europeans and by embedding innovation into European policies.

If K4G had achieved 'only' this, it would still have been judged a success. But I am happy to say that it leaves something more: a legacy to be proud of and – importantly – a stepping stone to build on.

And even more, I hope that the group's work and its ideas will continue to be important during the discussion and formulation of a post-2010 Lisbon strategy.

# Introduction

*Dominique Foray*[1]

The *Knowledge for Growth* expert group (*Group*), called into existence by European Commissioner J. Potočnik in March 2005, was tasked to provide advice and insight about the problems and issues that would promote the emergence and development of an efficient and effective European system of research and innovation. The goal was to move toward a system that could provide the European Community with the ability and capacity to profit from future technological revolutions, in contrast to lagging European performance in the case of the ICT revolution.

The gap between private and public R&D vis-à-vis the US and Japan, the relative decrease of the R&D-specific Foreign Direct Investment level in Europe, the apparent disorganization and perceived weaknesses of European universities and systems of knowledge transfer were central topics for initial discussion among the Group. This formed the core agenda for the work that commenced in July 2005 under the Chairmanship of Commissioner Potočnik with Bart van Ark serving as its vice-chairman.

But, within a relatively brief span of time, the policy context and issues forcing themselves upon the attention of the Group were dramatically altered. As a consequence the focus of the Group' activities evolved quite significantly during its life time. Of course the necessity of *improving* the conditions, organization and procedures of R&D and innovation in Europe has remained at the top of the agenda but the Group found that *responding* to the "Grand Challenges" through far-reaching R&D policy initiatives and *supporting* the whole innovation system in a new financial environment were also imperative. During the past three years the urgency of addressing climate change, health, and food supply problems through R&D and innovation has become increasingly salient. In addition, the financial and macro-economic crisis has created severe budget problems for many governments, reducing the funds available for addressing these longer term problems. Given these new and difficult circumstances, it became clear to the Group that it is not enough to proceed as usual with efficient and effective instruments to support public and private research, favourable framework conditions and an effective patent system. There is clearly a need today for far more ambitious R&D and innovation policies to put Europe in better position for overcoming the various crises of the age.

The new situation thus calls for a more complex agenda to address both the new matters at hand (structuring policy response to some urgent and global challenges; managing the new financial constraints) *and* the original mandate from the Commission (improving general conditions for R&D and innovation). One should note that the various parts of the agenda are completely intertwined: i) only an effective and efficient system of research and innovation would allow Europe to successfully respond to the global challenges posed above; ii) reciprocally, the seriousness of these challenges may foster collaborations between like-minded countries to credibly commit to R&D programs that need to be launched to address the global problems; iii) the mobilization of such resources, however, is likely to be adversely

[1] Chair of Economics of Innovation, College of Management at EPFL – Switzerland, and Vice-Chairman of the "Knowledge for Growth" Expert Group

affected by the financial crisis' impacts on the fiscal situation of the EU's Member States and the credit constraints on private sector investment.

The papers and briefs presented in this volume reflect the contribution of the group to these multiple agendas. They underscore five central points:

- Strategic complementarity of objectives and targets aiming at improving the research and innovation system. Strategic complementarity means that it is not wise to focus only on the goal of achieving 3% R&D intensity. This target remains relevant but as an incentive for a set of policy actions that need to be jointly implemented. By itself, the 3% target is unable to animate the system by generating positive response from the private sector if other structural changes are not made at the same time, for example, in the domain of financial markets and the supply of capital or in the domain of product markets, standards and competition.

- The key role of the young and fast growing innovators as great providers of the more heterodox, breakthrough innovations and a source of competitive pressure on incumbents, forcing them to invest in innovation. But acknowledging such a critical role implies seeking for the right institutions; i.e. adapted to the effective development of an economy of start ups, fast movers and new industries. The provision of tailored financing solutions to emerging firms and the design of mechanisms and policy to foster competitive entry in new industries and services are central issues in this institutional re-design.

- The centrality of diffusion policy to facilitate rapid adaptation and adoption of best technologies and practices across the European continent, improving its average operational efficiency. The focus on intra-European diffusion – a reprise of an enduring theme in the European history of invention and technical change – must be coupled with specialization strategies which would allow regions and countries to find their own relevant niche within the knowledge economy.

- The importance of developing an open, integrated and competitive European Research Area, and to effectively connect publicly supported researchers with interested counterparts engaged on R&D problems in the private, business sector. But, closer connections between universities and business should not be achieved at the cost of damaging the productive division of labour between the spheres of academic and publicly funded research institutions, on the one hand, and commercial enterprises on the other. Neither can excel at what they do the best when their goals and boundaries become blurred by requiring universities to seek patentable inventions as a means of financing their operating costs.

- The development and deployment of new strategic capacities and initiatives so that Europe can provide a structured and significant policy response to the Grand Challenges of our time. Here the policy goal is not only to influence *the rate* of innovation but also *the direction* of inventive and innovative activities. However it would not be very wise just to "copy and paste" the old (mission-oriented) policy structures of the 80s which were clearly detrimental to what has been recognized more recently as an extraordinary booster for innovation: entrepreneurship and young radical innovators (above). The challenge is in the policy design, in order to make these top down strategic initiatives compatible with market-driven resource allocation allowing for multiple decentralized experiments by new radical innovators.

The responsibilities of the Group's vice-chairmanship passed from Bart van Ark to me early in 2006, and I led the collective efforts during a second year of work on the issues that formed the initial agenda, and throughout its subsequent evolution in response to the growing centrality of the two kinds of crises that were reshaping policy making in the area of R&D and innovation. The studies, documents and discussions that emerged in this phase urged a number of new, broad policy position, and a number of them argued the case for specific directions of institutional reform. With the dissolution of the K4G Group at the end of its Chairman's term as Commissioner, it has seemed appropriate and relevant to bring together some of the key papers that reflect its policy analyses and longer-term recommendations and publish these in a convenient form for wider audience.

Despite the variety of the specific issues that occupied the attention of the Group's attention during the four year of its existence, the papers and documents[2] selected for this volume have a single, clear and unifying concern: the design and improvement of the institutions and organisations upon which our European society and economy must rely in order to produce and disseminate knowledge in an efficient way that will respond to global challenges and contribute to sustainable economic growth.

To close the introduction, I would like to express the Group's gratitude to M. Xabier Goenaga from the JRC-IPTS and to MM. Pierre Vigier and Werner Wobbe of DG Research for supporting the K4G work.

[2] Comprehensive information on reports, policy briefs and conferences of the *Knowledge for Growth* expert group is available under http://ec.europa.eu/invest-in-research/monitoring/knowledge_en.htm

# *PART A -*
# *ABOUT EUROPE's R&D DEFICIT*

# 1 - EU's R&D Deficit

*Mary O'Sullivan*[3]

*There has been a lot of focus on the concept of a deficit in research and development expenditures (R&D) in recent discussion on research and innovation policy in the European Union. The existence of a deficit is often used to suggest that there is a general problem with innovative activity in the EU, and concerted efforts are being made to induce European enterprises to spend more on R&D with a view to boosting economic performance through enhanced innovation. However, a close consideration of the R&D deficit challenges such a straightforward analysis of its implications for innovation policy. Instead, what we know about the nature of the R&D deficit, its causes and its implications need to be better appreciated if it is to serve as a useful guide in contemporary policy discussions in the EU.*

**What is meant by an R&D deficit?**

Business R&D expenditure in the EU is 30% below the US, and the €60 billion gap has not narrowed in the last five years. But at individual company and sector levels, there are numbers of EU companies that are investing as much in research as their US counterparts. For understanding the R&D deficit, industrial structure is a crucial consideration. The EU's deficit in R&D expenditures vis-à-vis the United States is one that primarily reflects a shortfall in EU R&D spending in the production of IT goods and services. This shortfall, in turn, seems to reflect characteristics of enterprise structure and dynamics, specifically the constraints on the rapid growth of new, technology-based entrants in the EU as compared with the US. There are reasonable grounds for concern that this pattern may be repeated in emerging areas of innovation, such as biotechnology. In short, the R&D deficit appears to be a symptom, rather than the cause, of weakness in the EU's capacity to innovate. The cause is rather the structure and dynamics of the region's enterprises and industries.

Question:
Are policies to raise R&D expenditures across all types of enterprises and industries in the EU appropriate to redressing the situation?

Given the role played by enterprise and industrial structure and dynamics in the R&D deficit, it becomes likely that policies that focus on overcoming barriers to innovation in specific industries and certain types of firms will be more effective than more generalised encouragement to increase R&D spending.

[3] *Mary O'Sullivan* is professor of economics at Wharton Business School (US)

**What causes the deficit?**

If policies are to be adjusted to redress the particular innovative problems of high technology sectors in the EU, then the reasons for these problems must be clearly identified.

> Questions:
> Why are EU firms weaker in technology-based sectors than US firms? And why are new EU firms less able to expand?

Perhaps the most common explanation for these differences is a greater willingness on the part of the US financial markets to fund new sectors and new firms. There is also greater flexibility of the US labour market, often identified as an important factor in spurring the emergence of new industries and new firms.
On the EU side, barriers such as the fragmentation of product markets and the attitudes of EU consumers to new products have also been cited as potential barriers to innovation.

This is a market-based view of the innovation system. It is also important to focus on the innovation system itself, and particularly how its various players, public and private, interact with each other. From this perspective, the relationship between the public sector, such as the defence and health systems, and industry is a crucial element. The long-standing and continued importance of the role of the US federal government in the defence and health systems, through procurement, R&D subsidies and other mechanisms, must be a major factor in the success of the IT, biotechnology and other dynamic, high-technology sectors.

Although these and other ideas abound about the causes of the deficit, most of them have not been tied in a rigorous way to the outcomes that they seek to explain. Moreover, many of the explanations seem more consistent with general shortcomings in R&D in Europe rather than the very specific problems highlighted for particular industries and types of firms. There seems little question that more work needs to be done to identify the general causal interactions and dynamics involved in the emergence of new industries if policy making in this area is to be systematic. This is particularly important since whichever causes are found to be the most salient, they will force research and innovation policy out of its normal realm if it seeks to redress them.

**Why does the deficit matter?**

> Questions:
> What has been the cost to Europe of falling behind in IT? Can it catch up? Are there lessons to be learnt for other emerging sectors?

Of course, the IT sector is long past its emergent phase and there may well have been important costs of the EU's falling behind that are hard to see now. Moreover, it may well be that a window of reasonable opportunity for catching up in IT has now passed. Nevertheless, a better understanding of what has been lost in IT would provide the context for understanding what might be lost again from falling behind in sectors that are only now emerging.

In examining how to address the R&D deficit and its structure, policy-makers need to be clear about the economic and social benefits that they hope to achieve by overcoming the EU's lag in new emerging industries. It ought not to be assumed that building a strong capability in the *production* of advanced technologies is necessary to exploit the gains from these sectors' technologies. Based on the example of IT, at least, much has been gained through the *use* of IT. Understanding how these gains might be exploited is, therefore, crucial to designing policies to overcome the EU's lag in this sector. Only if it can be shown that there is an important link between producers and users would efforts to further develop production capabilities in this sector be justified.

There should be a focus not only on economic outcomes but also on the social implications of the EU's lag in emerging technologies. Certainly, in cases such as biotechnology, nanotechnology and new materials as well as environmental technologies, the social implications of leads and lags seem just as important. However, there is a danger in overstating the role of advanced technology, in and of itself, as a salve for social problems. For example, existing research shows that advances in biotechnology do not translate automatically into improvements in healthcare. Therefore, further serious effort is required to evaluate the social costs and benefits of being leaders or laggards in fields such as biotechnology.

# 2 - Corporate R&D Returns

*Bronwyn H. Hall*[4] *and Jacques Mairesse*[5]

*Europe as a whole spends a smaller fraction of GDP on R&D than the US and Japan. The Lisbon strategy calls for increased R&D spending in Europe. This policy debate explores the possible areas and causes of underinvestment. Is there too little public spending or business spending? Should large firms or SMEs be encouraged to do more or does the problem lie in the sectoral composition of European industry?*

**Why does European R&D intensity appear low?**

In March 2000, the European Council in Lisbon set out a ten-year strategy to make the EU the world's most dynamic and competitive economy.[6] One of the main priority areas in the Lisbon strategy or Lisbon agenda (as it is sometimes known) is to increase investments in knowledge, research, and education, both by governments and by enterprises. Achieving this goal has been widely interpreted as calling for increased R&D spending in Europe, in order to attain a target in the neighborhood of 3 % of GDP overall.

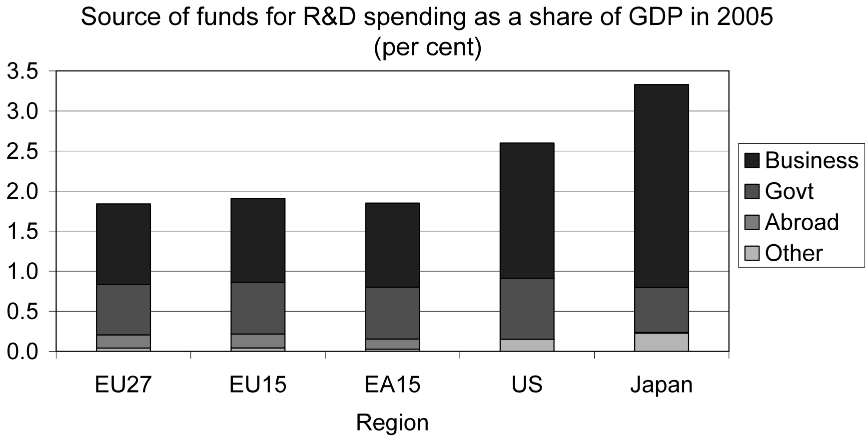
To make progress in moving toward this goal some questions need to be answered: In what areas does Europe have an R&D deficit? Why is this the case? Government policies, low expected returns, or high costs of capital? This "debate" considers these questions, provides some answers based on available evidence, and suggests areas where our knowledge is incomplete.

**The gap is larger in business R&D**

From Figure 1, which shows the composition of the R&D/GDP ratio in 2005 for three major EU regions (the 27 member countries, the 15 pre-accession member countries, and the 15 countries in the euro zone) along with the US and Japan, we can draw two conclusions: first, the 3% target lies somewhere between the performance of the US and Japan, and second, the shortfall is particularly striking for business R&D.

[4] Professor of the Graduate School at the University of California at Berkeley and Professor of Economics of Technology and Innovation at the University of Maastricht.
[5] Inspecteur General Honoraire at the "Institut National de la Statistique et des Etudes Economiques" (INSEE), and Professor of Applied Econometrics of Research, Innovation and Productivity at the University of Maastricht.
[6] http://europa.eu.int/comm/lisbon_strategy/index_en.html

**Figure 1**




However, some would argue that because the share of the economy in the public sector is larger in Europe than in countries such as the US and Japan, the government share of R&D spending should also be higher, suggesting that the shortfall is not only in business-funded R&D but also in public sector support of R&D. But the differences across the three regions seem rather small to account for the differences in the composition of R&D expenditure across region: according to the Heston-Summers data, the share of government in GDP is 17% in the EU, 16% in Japan, and 11% in the US.[7] Of course, the composition of government spending in the three regions also varies considerably, making precise comparisons difficult.

Mention should be made of another increasingly important phenomenon and its implications for Figure 1, the internationalisation of R&D performance. The data for the US and Japan in Figure 1 uses R&D sourced by business but performed within the relevant national borders. That is, US firm R&D conducted in Europe is counted as European R&D. Using some statistics on the top 1000 R&D performers worldwide available from a recent report by Booz & Co., it is possible to form an impression of the size of the discrepancy for the US and Japan (that for Europe is small, around 2% of total spending).[8] In 2008, adding in R&D performed by US firms outside the US and subtracting R&D performed by non-US firms in the US would increase US business R&D intensity from 1.65 to 2.2%. For Japan, the corresponding figures are 2.5 to over 4%. Note that these estimates are based only on the largest firms so that they are probably an overestimate, but the fact remains that correcting for this problem only increases the EU gap.

The larger question is whether increasing R&D spending in Europe to US and Japanese levels is the appropriate target for policy to improve European innovative performance. Although this brief does not take a position on this question, it deepens understanding of the reasons for the business R&D "deficit", in order to inform us about the innovative process in which R&D does play a large part.

---

7 See Heston, A., R. Summers and B. Aten, *Penn World Table Version 6.2*, Center for International Comparisons of Production, Income and Prices at the University of Pennsylvania, September 2006.

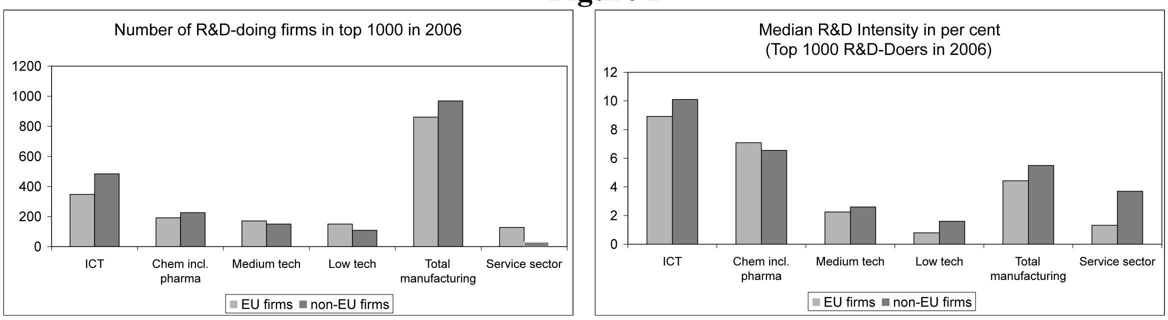
8 See Jaruzelski, B., and K. Dehoff, "Beyond Borders: The Global Innovation 1000," *strategy+business magazine* issue 53: 53-67, Booz & Co., 2009.

**Looking inside the business R&D gap**

In an earlier paper written for this group, O'Sullivan reviewed the evidence on the source of an R&D deficit at the EU level and concluded that the differing importance of the Information and Communication Technology (ICT) sector was responsible for the bulk of this deficit between the EU and the US. There was also evidence that this sector accounted for differences in the share of young fast-growing firms between the two economies. Here we look at the top-1000 R&D-doing firms in the EU and compare them with those outside the EU.[9] We note that this comparison is different from that shown in Figure 1, as it focuses on R&D classified by the location of the firm's headquarters, rather than by where it is performed.

Figure 2 shows the composition and R&D intensities of the two groups of firms, EU and non-EU.[10] The conclusions that emerge from this figure confirm the analysis in the earlier paper.
1) Among top-1000 R&D-doing firms, there are fewer ICT firms and more service firms in the EU in comparison with the rest of the world.
2) In the EU, the R&D intensity of the typical firm is also lower in ICT firms and much lower in service sector R&D-doing firms than in the rest of the world. When one examines the composition of these two broad sectors in terms of industry and individual firms, one can see that this is due to differences in firm strategy within particular sectors, with firms outside the EU being more high technology-oriented. For example, several of the US service sector firms provide electronic services to financial service firms (Fiserv, Convergys, Automatic Data Processing).

**Figure 2**




9 European Commission (2008). *EU R&D Investment Scoreboard*. Luxembourg, Office for Official Publications of the European Communities.
10 In making these figures, we reclassified a few internet or technology-intensive firms such as WebMD, Expedia, Tivo, etc. into the ICT sector from the Service sector.

Overall, the median R&D intensities of these two groups of large firms are 5.4% outside the EU versus 3.7% in the EU.

Conventional wisdom in this area also says that Europe does not have enough small and medium-sized firms that perform R&D. Although this might be true, it does not account for the measured R&D deficit. A comparison of the R&D-weighted size distribution with that of US and the Japan shows that firms with fewer than 250 employees account for 19% of R&D in the EU15, 14% in the US, and 8% in Japan.[11] This fact suggests that it would be worthwhile to focus a more careful analysis on the size issue – is this result real or a consequence of faulty measurement? If it is real, why is there a perception that European SMEs do too little R&D?

**Private R&D returns are slightly lower than in the US**

If business R&D spending is indeed "too low" in Europe, simple economic analysis tells us that this might be for two reasons, both of which can occur together: supply of funds problems (too high a cost of capital) and/or R&D demand shortfalls (firms do not find opportunities that are profitable enough, or they find the cost of R&D inputs too high). From the perspective of policy, one needs to measure the marginal returns to R&D to decide which problem deserves the most attention. That is, if the rate of return to R&D among European firms is found to be high, that suggests that the cost of capital they face is high and requires that attention be paid to the functioning of financial markets. If the rate of return to R&D is found to be low, then our attention is directed to a number of other areas that influence the opportunities for R&D investment - the size of the market, entrepreneurship, regulation, the role of standards, the cost and availability of R&D labor, the presence of lead markets, and so forth.

There does exist considerable evidence on the rates of return to R&D for firms in individual countries. We have collected these estimates on a single chart shown in Figure 3. This figure shows cross-sectional estimates for the private gross rate of return to R&D capital from a number of European countries (France, Germany, Italy, Denmark, and the UK) along with the US for comparison. The samples of firms used are generally the largest R&D-doers. Although there is considerable dispersion in the estimates, the majority cluster around 0.15 to 0.35.[12] The figure shows that the return to R&D in large EU firms have been generally below those for US firms in the period since the mid-1990s, ruling out the high cost of capital explanation for firms that already do R&D.[13] Also note that the data points for 2006 are estimates using data from the EU and US top 1000 firms, and it is striking that the estimates for these samples, which are based on similar methodologies, are so close.

---

11 OECD (2008). *OECD Science, Technology and Industry Scoreboard* 2007. Paris, France. Relative to GDP, these figures are roughly 0.2%, 0.23%, and 0.2% for the EU, US, and Japan respectively.

12 One reason for the high variability is that the methodologies used to obtain the estimates are not always identical; a second reason is that *ex post* rates of return to R&D are estimated imprecisely and may vary greatly over time, reflecting the uncertainty inherent in innovative activity.

13 ICT firms generally exhibit higher (gross) rates of return due to the rapid depreciation of R&D investment in that sector. Therefore we would expect the average rate of return to be somewhat lower in the EU than in the US, reflecting the lower ICT share of the R&D-performing sector.

The conclusion of this analysis is that for the large firms that do R&D, rates of return are not obviously different between the EU and US. Any underperformance must lie elsewhere. Evidence from Cohen and Lorenzi (2000) suggests that one difference between the EU and the US is the number of young firms among the large R&D-doers in the latter region.[14] That is, among the top 200 R&D-doing firms in the US, accounting for 80% of business R&D, almost half are 20 years old or younger and started quite small.

**Figure 3**

Cross-sectional estimates of the private firm-level rate of return to R&D


**The debate**

When taken together with the previous work on these questions by O'Sullivan, the preceding analysis reaches the following conclusions:

- There are fewer ICT firms in Europe, and ICT is very R&D-intensive, which explains a large share of the differences in business-funded R&D shares.

- Even among non-ICT firms, there are fewer innovators applying new ICT technologies to other sectors, and those there are do not grow large.

- Related to point (2), there are fewer young European firms among the large R&D-doers.

- It is possible that the R&D deficit is not solely due to business-funded R&D.

Nevertheless, the following appear to be true and rule out simple explanations:

- According to sources from corporate statistics average returns to R&D are not obviously higher (or lower) than in the US for those firms that do R&D.

- Roughly the same amount of R&D is conducted by SMEs in Europe as in the US or Japan.

---

[14] Cohen, E., and J.-H. Lorenzi (2000), *Politiques industrielles pour l'Europe*, rapport du CAE, no. 26, La Documentation française.

Therefore, it is natural to ask whether the problem is with R&D *per se.* Or should one look elsewhere for the explanation of what appears to be weaker innovative performance, perhaps at differences in labor or entry regulation, or at the failure to create a Venture Capital sector that is capable of financing fast-growing firms, or at some other cause?

**R&D spending as investment**

*R&D spending is both similar to and different from ordinary investment. The similarity is that it is expenditure undertaken today to secure (uncertain) returns in the future, which is why it is referred to as "R&D investment" and why analysis of the R&D decision frequently uses the tools of investment analysis. The differences lie in the level of uncertainty, which is much larger, the public good nature of much research (it is useful to other firms as well as to the firm that performs it, and the fact that once done, the information produced can be used at almost any scale).*

*A second difference between R&D and ordinary investment creates some difficulties for analysis and interpretation: in the case of R&D, there is no well-developed second-hand market that would allow us to infer the price of R&D separately from its quantity, and to establish an independent measure of depreciation. Therefore R&D spending is usually deflated by the overall GDP deflator, and no account is taken of increases or decreases in its productivity in creating a stock of firm-based knowledge. This is why the analysis of the supply and demand for R&D is in terms of nominal rather than real quantities.*

***PART B -***
***HOW TO OVERCOME THE DEFICIT***

# 3 - Smart Specialisation: The Concept

*Dominique Foray[15], Paul A. David[16] and Bronwyn Hall[17]*

*This brief introduces the basic concept of "Smart Specialisation" (SS) which has been a leading idea of the Knowledge for Growth expert group (K4G). The concept is spelled out in more detail in Policy Brief N° 1[18] in relation to globalisation. Other K4G Policy Briefs that refer to the concept are those on Catching-up Member States (N° 5) and on technology and specialisation (N°8).*

***Rationale for invigorating the R&D specialisation policy discussion***

Addressing the issue of specialisation in the R&D and innovation is particularly crucial for regions/countries that are not leaders in any of the major science or technology domains. Many would argue that these regions/countries need to increase the intensity of knowledge investments in the form of high education and vocational training, public and private R&D, and other innovation-related activities. The question is whether there is a better alternative to a policy that spreads that investment thinly across several frontier technology research fields, some in biotechnology, some in information technology, some in the several branches of nanotechnology, and, as a consequence, not making much of an impact in any one area. A more promising strategy appears to be to encourage investment in programs that will complement the country's other productive assets to create future domestic capability and interregional comparative advantage. We have termed this strategy "smart specialisation."

Smart specialisation is expected to create more diversity among regions than a regime in which each region tries to create more or less the same in an imitative manner. The latter would almost certainly result in excess correlation and duplication of R&D and educational investment programs, which in turn would diminish the potential for complementarities within the European knowledge base. It is both an idea and a tool to help regions or countries to answer this critical question about their respective (and unique) positions in the knowledge economy.

---

[15] Chair of Economics of Innovation, College of Management at EPFL – Switzerland, and Vice-Chairman of the "Knowledge for Growth" Expert Group
[16] Professor of Economics at Stanford University, Professeur Titulaire of Innovation & Regulation in the Digital Economy at Ecole Polytechnique and Telecom Paris Tech.
[17] Professor at the University of California at Berkeley and Professor of Economics of Technology and Innovation at the University of Maastricht, Netherlands.
[18] Reports and Policy Briefs of the K4G expert group are to be found at: http://ec.europa.eu/invest-in-research/monitoring/knowledge_en.htm

***One simple idea***

It should be understood at the outset that the idea of smart specialisation does not call for imposing specialisation through some form of top-down industrial policy that is directed in accord with a pre-conceived "grand plan". Nor should the search for smart specialisation involve a foresight exercise, ordered from a consulting firm. We are suggesting an *entrepreneurial process of discovery* that can reveal what a country or region does best in terms of science and technology. By this we mean a learning process to discover the research and innovation domains in which a region can hope to excel. In this learning process, entrepreneurial actors are likely to play leading roles in discovering promising areas of future specialisation, not least because the needed adaptations to local skills, materials, environmental conditions, and market access conditions are unlikely to be able to draw on codified, publicly shared knowledge, and instead will entail gathering localized information and the formation of social capital assets.

As pointed out by Hausmann and Rodrik in a recent paper, this activity poses a public policy problem.[19] The discovery of pertinent specialisation domains has high social value because it helps to guide the development of the region's economy. But the entrepreneur who makes this initial discovery will only be able to capture a very limited part of value of the information generated by his investment because other entrepreneurs will swiftly move into the identified domain. Furthermore, entrepreneurial individuals that are well-placed to explore and identify new activities often will not have sufficient external connections to marketing and financing sources and are likely to find themselves in a weak position when negotiating with these external parties for the resources need to expand their young enterprise, reducing their incentives to enter in the first place. Thus there is a potentially serious incentive problem that is not susceptible to resolution by resorting to protection via intellectual property rights. The resulting tendency toward under-investment in this particular type of "discovery process" warrants considering what corrective role can be filled by public policy measures to support greater engagement on the part of locally situated entrepreneurs.

Beyond trying to address this incentive problem, policy makers should accept that their role in "selecting the right areas for specialisation" may be a more modest one than is usually envisaged when support for infant industries and support for technology start-ups are under discussion. Public entities can play an important infrastructural role by providing and collating appropriate information about emerging technological and commercial opportunities and constraints, product and process safety standards for domestic and export markets, and external sources of finance and distribution agencies. Assisting local entrepreneurs to coordinate in forming mutually reinforcing connections and pool generic knowledge that will accelerate this discovery process may also be helpful activities.

***One simple tool***

The specific properties of *General Purpose Technologies* (GPTs) define *a framework that helps to clarify the logic of Smart Specialisation (SS).* While major innovations often result from the commercialization of a core GPT invention, and its successive technological elaborations – such as the double-condensing steam engine, the electric dynamo, the internal combustion engine, or the micro-processor, there myriads of economically important

[19] See Hausmann, R. and D. Rodrik, "Economic Development as Self-Discovery," *Journal of Development Economics* 72(2003), 603-633.

innovations that result from the « co-invention » of applications (steam-ships and locomotives, arc-lamps and AC motors, software applications for mobile phones, etc.) In fact, the characteristics of a GPT are horizontal propagation throughout the economy and complementarity between invention and application development. Expressed in the words of an economist, invention of a GPT extends the frontier of invention possibilities for the whole economy, while application development changes the production function of a particular sector. The basic inventions generate new opportunities for developing applications in particular sectors. Reciprocally, application co-invention increases the size of the general technology market and improves the economic return on invention activities relating to it. There are therefore dynamic feedback loops in accordance with which inventions give rise to the co-invention of applications, which in their turn increase the return on subsequent inventions. When things evolve favourably, a long-term dynamic develops, consisting of large-scale investments in research and innovation whose social and private marginal rates of return attain high levels. *This dynamic may be spatially distributed between regions specialised in the basic inventions and regions investing in specific application domains.*

This framework suggests strategies that can be pursued with advantage both by regions that are at the scientific and technological frontier, and by those that are less advanced. While the *leader regions*[20] invest in the invention of a General Purpose technology (GPT) or the combination of different GPTs (bioinformatics), *follower regions* often are better advised to invest in the « *co-invention of applications* » - that is – the development of the applications of a GPT in one or several important domains of the regional economy. Some examples would be biotechnology applied to the exploitation of maritime resources; nanotechnology applied to various agricultural and food sectors such as wine quality control, fishing, cheese and olive oil; information technology applied to the management of knowledge about and the maintenance of archaeological and historical patrimonies. By so doing, the follower regions and the firms within them become part of a realistic and practicable competitive environment -- defining an arena of competition in which the players are more symmetrically endowed, and a viable market niche can be created that will not be quickly eroded away by the entry of larger external competitors. The human capacities and resources formed by the region, thanks in particular to its higher education, professional training and research programmes, will constitute « co-specialised assets » – in other words the regions and their assets have mutual needs and attraction for one other – which accordingly reduces the risk of seeing these resources go elsewhere.

By using the GPT framework, we hope to make clear that smart specialisation is not to be associated with a strategy of simple industrial specialisation of region X in, for example, tourism. Smart specialisation is about *R&D and innovation specialisation* and what it suggests for region X is to specialize in the co-invention of ICTs application in the sector of tourism, for instance the development of advanced booking website in order to improve the quality of some services and reduce queuing. ..

***Implementation and policy***

Finally, *there is a role for governmental S&T policies,* but it is not that of bureaucratically selecting areas of specialisation and fostering the development of "national champions" in inter-EU competition. Instead, governments have three main responsibilities:

[20] We distinguish between "leader regions" that master the technological frontier, follower regions that are able to catch up to a leader region and laggards who struggle to build up absorptive capacities to apply advanced technologies (see Policy Brief N° 5 on catching-up countries).

- Supplying incentives to encourage entrepreneurs and other organisations (higher education establishments, research laboratories) to become involved in the discovery of the regions' respective specialisations. The incentive framework is essential since the social value of the knowledge produced is very high and entrepreneurs who make this kind of discovery are likely to capture only a negligible share of this social value.

- Evaluating and assessing effectiveness so that the support of a particular line of capability formation will not be discontinued too soon, nor continued so long that subsidies are wasted on otherwise non-viable enterprises. The challenge is to prevent the evaluation process from being captured by the interests that are benefiting from the program or by rivals who would like to see it discontinued. Obviously assessing ex ante the future value of R&D specialisation is a quasi-impossible exercise. So the national agency in charge of this policy should confine themselves to ascertaining whether two criteria are satisfied before initiating the usual policy tools to support R&D and innovation: i) what is the potential of the GPT to regenerate the targeted economic domain (production or services) through the co-invention of applications? ii) Is the size of this domain large enough (the size refers here not to GDP but to the size of the *relevant* sectors in the economy, that is, those sectors that could potentially benefit from the knowledge spillovers from the initial development of applications)? The latter question opens the issue of the *connectedness* of the targeted economic domain: R&D domains with high connectedness to other domains will create greater opportunities for future structural transformation (it is better to occupy the rich parts of the forest where it is easier to jump to other trees).

- Identifying complementary investments associated with the emerging specialisations (educational and training institutions, for example) in the case of a region investing in the co-invention of applications of a General Purpose Technology (GPT). *Many regions in Europe are characterized by weak correlation between the R&D and training specialisation and the structure of their economic activities*. There is a role for government to improve this relationship. This implies supporting the provision of adequate supply-responses (in human capital formation) to the new "knowledge needs" of traditional industries that are starting to adapt and apply the GPT, by subsidizing the follower region's access to problem-solving expertise from researchers in the leader region, and by attending to the development of a local personnel that can sustain the incremental improvement, as well as the maintenance of specialised application technologies in the region.

- Promoting GPT networks might therefore be an important policy issue at the EU level. Such networks are not the ones which only involve the population of the "superstars" of a given field. These are networks between very heterogeneous agents – the ones from the leading knowledge centres and the ones from the more peripheral regions aiming at co-inventing applications. Many incentive and coordination problems can arise in such a situation, because working with "an old industry" in a remote region is not likely to hold great attractions as a career move for the scientists, engineers and business managers that are in the "leader regions," yet access to their knowledge may be vital in the early stages of the "application enterprise." How does one help solve this problem in a "generic" fashion that does not turn into a government subsidy for the development of a particular industry in a specific region? This is one instance of a class of difficult issues that frequently occupy the attentions of economists and experts from international organizations like the World Bank that work in developing regions. Possibly the resolution in this case lies in the idea that there are phases in smart specialisation where temporary "industrial policy" measures, such as infant industry policies, are warranted.

It will help to provide an example that illustrates the ways in which national public policy has an important role in supporting and accompanying emerging trends in smart specialisation. The Finnish Pulp and Paper (P&P) industry views nanotechnology as promising source of valuable applications innovations, and its firms are taking steps to assess this potentiality. Some of the P&P companies are responding to these opportunities by increasing their overall internal R&D investments, which are aimed not only at implementing available technologies but also explore recent advances in areas of nanotechnology and biotechnology. Analyzing this development along the two criteria mentioned earlier (the potential of the GPT to renew the knowledge base of the industry and the size of the sector that could benefit from the spillovers generated by the initial discovery), there is an obvious role for national policy in enhancing the whole process and mitigating some of the problems (such as lack of human capital) that could impede the full realization of the potential for disruptive technological change in this "old industry".[21]

[21] Nikulaien (2008) shows how patent data can be used to a certain extent to assess the progress of the industry toward smart specialisation by looking at the increase in patent applications by P&P firms related to nanotechnology. See T. Nikulainen, "Open innovation and nanotechnology - an opportunity for traditional industries," Working Paper, The Research Institute of the Finnish Economy, Helsinki, April 2008

# 4 - Technology and Specialisation: Strategies, Options and Risks

*Tassos Giannitsis*[22]

*Technical change and innovation have been powerful engines for enhancing 'dynamic' specialisation advantages of firms and industries and constructing 'differences' vis-à-vis competitors, achieving cumulative growth, rents and power. In a period of crisis, specialisation strategies can be conducted in ways that also enhance innovative specialisations and competitive advantages in the post-crisis period, facilitate repositioning strategies and underpin answers to severe global risks (e.g. energy shortage, climate change).*

*Specialisation strategies are based on technical change and innovation and they contain options and policy risks. Therefore, strategies have to consider the heterogeneity of research and technology specialisation patterns in the E.U. as well as divergent policy goals. Also, a distinct and adapted strategy is required responding to the related risks and opportunities. Eventually, the policy action should consider a risk management approach and draw on the concept of "portfolio management" adjusted to RTD policies. '"portfolio management" adjusted to RTD policies.*

**The heterogeneity of research and technology specialisation patterns in the EU and policy goals**

The lagging position of the EU in frontier technologies coupled to its internal diversity resulting from the different research and technological capabilities of its member countries are at the origin of many policy concerns at both the E.U. and the national level.

In fact, the EU's position in emerging technologies is likely to replicate the experience with ICT and bring Europe once again in the position of a laggard. It appears that there is a structural barrier preventing Europe to become leader in emerging frontier technologies. In many areas European technology advancement appears to be comparatively either "too little" or "too late". What is the policy lesson? Is it possible to reverse this trend and how? Can either a positive or a negative answer be given at zero social cost or risk? If not, what are the policy implications?

[22] Professor at the University of Athens, Department of Economics. This Policy Debate Brief is mostly based on the report of Tassos Giannitsis and Marianne Kager "Research and Technology Specialization: What policies?" and T. Giannitsis, "Towards an Appropriate Policy Mix for Specialisation", in D. Pontikakis, D. Kyriakou, R.Van Bavel, " The Question of R&D Specialisation: Perspectives and Policy Implications" (to be published, 2009).

External and internal divergences justify different mixes of approaches to specialization rather than one-size-fits all strategies. The EU's strategies are focusing on three major challenges:

- to make the EU "the most dynamic and competitive knowledge-based economy in the world",
- to narrow internal discrepancies and enhance convergence, and
- to deal with global risks and prevent large systemic risks in areas of major public concern such as energy and climate change.

However, issues to be dealt with are not only technological. They are more complex, linking effective governance, coordination of research and technology policy, knowledge building and the shaping of productive processes. In addition, knowledge and technology factors are not related to specialization in a linear way, making the game of who can create competitive positions complicated. In fact, technology factors are integrated into the different parts of the complete value chain of firms in very different ways. The success depends on how technology inputs interact with very diverse locally available labour forces, capital or other inputs and, in particular, the prices of these. The reality shows that firms can achieve diverse combinations between technology and the various elements of their value chain and construct very different and unpredicted specific or niche competitive advantages.

**Three different strategies**

Different goals call for different technology- and innovation-related specialisation strategies. Three main strategies can be identified:

a) Strategies for technological leadership (strategies aiming at the frontier),
b) Catching-up strategies for (fast or slow) followers,
c) Preventive strategies to address global risks.

The implementation of all three types of strategy can take a more targeted (pro-active) or a more neutral (re-active) form. In particular, strategies to enhance specialization in emerging technological fields (type a and b), raise a dilemma between selection and non-selection in the policy-making process. It can be argued, that the goal to aim at the frontier and to address global challenges seems to favour a policy mix with more pronounced targeted approaches, while catching-up strategies call for rather more horizontal policy mixes. However, it would be misleading to consider specialization policies in absolute and/or dichotomic terms. In fact, even neutral policies include selections. What determines the success is the pragmatic mix between active and neutral approaches and the interactions between policy and its environment. Additionally, the more technologically advanced the environment is, the more these strategies coexist within the same national space, as they serve the parallel goals of the same actor.

In addition to the production of technology, specialization policies should also give emphasis to diffusion aspects, which are often underrated. In the presence of weak trickle-down mechanisms, new technologies and knowledge will have a limited success in leveraging new specialization, competitiveness and growth. Diffusion of technologies, for different reasons, is crucial for both, convergence strategies and strategies aiming at the frontier.

(a) Strategies aiming at the frontier

*The rationale*:

- Early specialisation in emerging technological and the related productive areas leads to significant benefits of both economic and non-economic nature,
- Frontier technologies develop over many decades and historical experience shows that rarely, if ever, such technologies can develop without strong public support mechanisms,
- Risk-aversion policies leading to latecomer positions in core technologies often have adverse implications for growth, employment and competitiveness, which last for a long time, are difficult to reverse and affect economic and social performance.

*The dilemma*: Specialisation strategies aiming at the frontier unavoidably raise a selection dilemma: which areas to enhance? The Lisbon strategy implicitly calls for policies to develop capabilities on those scientific and technological trajectories, the dynamics of which drive forward economic growth and welfare in the present phase {???). Hence, the various high tech areas (and, selectively, for medium to high tech) implicitly occupy a central place in the implementation of the Lisbon and ERA strategies. In fact, various thematic areas and other initiatives constitute significant priorities of the Framework Program or of the EU's broader research and technology policy.

*The risks:* Technology and innovation policies along these directions imply different risks. Policies aiming at frontier technologies face increased risks because of weak path-dependencies. The high uncertainties for private actors in such situations can make intervention appropriate, but not necessarily any less risky.

*The options*: To deal with such risks, policy could be structured along three broad axes:

a) To target 'winning situations', by leveraging the success of clusters of market players in particular technological, knowledge and specialization areas, based on market-led pre-selection, the evolving market evidence and in cooperation to market agents. What matters is to spark and to underpin a self-sustained cumulative development of new specializations.
b) To broaden the policy spectrum by "evolutionary targeting"[23], in the sense e.g. to assure a critical mass of capable market agents, to target the emergence or to leverage the success of new multiagent structures (or clusters) in particular areas, and
c) to combine a) and b) with smart policy initiatives and specializations.

The concept of smart specialisation[24]:

- indicates a successful fine-tuning of policies envisaging the creation of innovative competitive units, clusters and/or regions,
- implies interventions and, hence, some explicit or implicit targets coupled to an intended concentration of resources in some form,

[23] D. Avlimelech, M. Teubal, (2008), Evolutionary targeting, J. Evolutionary Economics, 151-166.
[24] Foray, 'Les nouveaux centres mondiaux dans le domaine de la recherche et de l'innovation: vers une economie de la specialisation intelligente (FutuRIS, 2008)' and 'Understanding "smart specialization" (July 2008)'.

- makes necessary financial support mechanisms, which can generate extensive positive social externalities in the future,
- assumes that there are criteria to judge which specialisations and, consequently, which policy targets are smart.

An issue to be tackled is that, in particular regarding new technological areas, smart policies can be acknowledged as such only after their success starts to become visible, while ex ante it is very difficult and/or risky to define success criteria and to assess the combined outcome of market and policy processes.

b) *Preventive strategies to face global risks*:

In this phase societies are faced with the need to develop technological solutions for dealing with qualitatively new global risks (climate change, energy, environmental issues), which enter more and more in the world agenda[25]. The crisis accelerated this process. In fact, what is at stake today for leading actors differs from the race to create new knowledge as an engine for growth. The difference is that there is an urgent social demand to find solutions within predetermined time limits, if social costs have to be kept within an acceptable range.

One difficulty is that in the case of expected global risks it is inherently difficult to have an ex ante measure of what is success or failure. How to measure future costs and benefits e.g. from the development or not of alternative energy technologies? Nevertheless, policies of selection and risk taking are necessary - 'non-selection' will also have risks and costs. The risk of inaction or of delay in the support of advancing critical technologies could be larger than the cost of action. It could be significant in terms of growth, income, employment, competitiveness, market positions and environmental degradation. It could have adverse economic and social effects nationwide and EU-wide.
In such a blurred landscape, a significant difference between more targeted and neutral specialization strategies might be that for the latter, broader systemic failures to meet timely major risks, can become a certainty rather than being only a probability. The issue is that additional criteria for decision making are necessary, but of which kind?

c) *The catching-up and the convergence issue*:

In contrast to advanced technology systems, the absence of co-evolutionary processes between technologies, institutions, business activities and public policies in technologically weaker players increases the policy risks and uncertainties, in particular in the case of more targeted interventions. Equally, in weak technology systems the cause-effect relationship between specialization and technological mastery is reciprocal. For technology specialization to be transformed into competitive advantages there is also need of a sufficient level of expertise over the broader scope of the related technological base. Hence, while the weak market signs increase the unpredictability of where it might be good to specialize, policies regarding followers should be flexible, gradual and avoid the risk to prevent or to deter efforts to build capabilities and specializations in promising fields.

[25] "European research policy … besides the pursuit of scientific excellence, should support knowledge advancement and dissemination and underpin policies … in fields of major public concern such as health, energy and climate change" (ERA Green Paper).

Notwithstanding successful examples, horizontal policies appear to be a less risky approach for technologically weaker systems. They generate decentralized selection mechanisms, learning processes and a diversification of specialization patterns, while they also facilitate innovative forms of combinations between technological knowledge and local factor capabilities.
From a different perspective, however, EU's strategic choices regarding frontier technologies or technologies targeting global risks should avoid restraining followers from developing new capabilities for these countries' technology areas. Technological evolution and application are non-deterministic and even what appears as duplication often creates diversity and distinctive capabilities and/or new opportunities. In other words, although targeted policies can be appropriate in a positive sense (e.g. to support the acceleration of technological advancements), they can have adverse effects if their consequence is to raise barriers, to concentrate resources in leading areas, to exclude certain actors, to limit windows of opportunity, the building up of new capabilities or the development of specializations of followers in promising technology areas.

**What are the choices and how to deal with the risks?**

Frontier research is not a question of the spending as a percentage of GDP but of having smart goals and policies as well as appropriate, absolute amounts of financial and human resources. Evidence shows that voluntary top-down approaches have often failed, but also that neutral policies often have a failure cost, but that this is less transparent. The success of both, target-related and neutral strategies depends largely on the articulation of the policy mix and the definition of the objectives.

Faced with these different asymmetries of information, risks and opportunities, policy making can be addressed as a risk management issue drawing on the idea of *'portfolio management'*, adjusted to RTD policies. Portfolio management approaches favour variety and selection mechanisms. It can reduce risks and assess the multiple research and technology objectives on the basis of such criteria as financial cost, probabilities of success, externalities and/or social costs and benefits. The question is how to shape targets and choices, to better reflect a politically desired balance of policies, social risks and benefits. In view of the three major E.U. challenges the question are: if and what new policy concepts have to enrich or to enhance the existing policy-making process? And how policy could better succeed in organizing a flexible and diversified framework and implementing specialisation targets?[26] Success is determined by the co-evolution of a range of elements, such as:

- An appropriate coordination at European level of public organisations, business firms and research communities,
- The design of priorities on selected areas and a package of policies to support the research activities of firms and organizations and to cooperate closely with the business sector and the scientific community in detecting needs, capabilities, technological trends, key discoveries, possible advancements,

[26] Pro-active policies at the EU (and national) level can aim at a 'research friendly ecology' (Georghiou, 2007), combined selectively with a 'cluster-specific environment'.

- For the evaluation of success, the selection of priorities as well as other policy strategies has to consider externalities - positive as well as negative ones-, like climate change, energy supply and environment issues. Within the concept of portfolio management, the effects of these externalities have to be explicitly taken into account,
- The broadening of criteria on the basis of which the success of research and technology specialization policies can be assessed,
- The enhancement of variety creation and the selection and support of differentiation elements vis-à-vis competitors.

The ERA can facilitate the development of a range of high-tech milieus with internal and external interactions, linkages with business partners, public research organizations and communities of joint research and technology targets. Such poles of excellence could support the promotion of emerging new technologies with crucial economic and/or social implications. The development of such high tech milieus is justified from the critical mass of resources (financial and human, physical and soft infrastructures) which are needed but cannot be provided in the framework of existing policies at lower levels of governance. In such a way the ERA can enhance research and technological change, enabling both the leveraging of continuous change, adaptation, and competitive strengthening of industrial structures as well as the unfolding of emerging new technology fields.

# 5 - How to Better Diffuse Technologies in Europe

*Georg Licht*[27]

*The Lisbon Strategy puts emphasis on R&D policies with its 3% target in order to become the most knowledge intensive economy. These goals of the Member States within the European Research Area could be supported by increased technology diffusion policies such as:*
*- Setting up knowledge transfer institutions,*
*- Development of Higher education and lifelong learning,*
*- Awareness arising about technology diffusion management,*
*- FDI encouragement for knowledge transfer and best management practices.*
*Diffusion policies would be of benefit in particular to the catching-up countries that lack resources to reach the 3% target and need to develop absorptive capacities to adopt advanced technologies faster.*

The member countries of the European Research Area (ERA) and the EU Commission have put innovation at the top of the policy agenda. The Lisbon Strategy includes the ambitious 3% target for national R&D intensity and national government have turned this into their own national goals. Governments have begun new initiatives and new policies to increase spending on R&D by both public and private sector. Supporting R&D and, thus, invention and innovation is just a first step. To achieve additional employment and income growth, R&D must be transformed into new products, processes and technologies which are adopted by firms, households and governments. The factors which enhance the implementation of new knowledge can be quite different from the factors which stimulate invention and innovation. The question at stake for catching-up countries may be in view of economic growth and employment the priority for investments in technology creation by R&D or investments in institutions that favour the diffusion of technology.

Invention, innovation and diffusion are not necessarily intertwined. The history of technology is full of examples demonstrating that countries, firms and individuals which were leading in invention are not necessarily also leading in innovation or in the widespread diffusion of new technologies. One well known example is the fax machine, which was first developed in Germany but was turned into a worldwide successful product by Japanese companies. Similarly, the anti-lock brake system (ABS) was invented by US car makers but became prominent primarily due to German automotive suppliers.

The worldwide diffusion of information and communication technologies (ICT) has significantly reduced the barriers to access information and has speeded up the diffusion of knowledge on recently developed technologies. This might make one think that the location

[27] Director of the "Industrial Economics and International Management" department at the Centre for European Economic Research (ZEW), Mannheim.

of invention is no longer important to the successful transformation of invention into employment and income growth.

First of all, the fashionable idea that we live in a completely networked, dematerialized information society is not the best starting point and not a satisfactory basis for policy making. The adoption of a new technology often takes longer than the diffusion of knowledge. Diffusion of innovation is still a gradual process involving significant time and adjustment costs. Often, old and new technologies exist in parallel for a long period during which both are incrementally improved and adjusted.

Empirical evidence suggests that technology diffusion still has a locational component. Innovations are usually generated in high-income countries which are also the starting point for diffusion. Neighbour countries, trade partners (especially in the field of advanced capital goods) or countries with strong social ties to each other more rapidly adopt new technologies from the leading countries.

However, the speed of convergence of international technology adoption has significantly increased in the last decades. And so, the time advantage from which countries can profit from faster technology adoption has now become notably smaller. Despite a considerable heterogeneity across technologies, the overall pattern of international technology diffusion suggests that countries which are leaders in the adoption of a forerunner technology will also become leaders in the adoption of the next generation technology. In view of ERA this trend may receive policy attention to offering development potential for catching-up regions and countries.

To improve technology diffusion, the absorptive capacities for new technologies have to be increased. In this context, knowledge transfer institutions play a crucial role like for example the Fraunhofer institutes in Germany, TNO in the Netherlands or Innova in Sweden. In addition to supporting knowledge transfer institutions which also may have a role in R&D, governments should also target three policy areas, namely education, the improvement of management practices, and FDI as a mechanism for technology diffusion.

**Support technology diffusion by investments in education**

Several studies have frequently examined the role of human capital in technology diffusion. Economies with highly educated workers may be more capable of quickly and efficiently adopting new technologies. Therefore, the most obvious candidate to explain the successful adoption of technologies is the level of education of the workforce.

Looking at more recent technologies, *tertiary education* plays an important role in fostering technology diffusion. For example, empirical studies suggest that the diffusion of ICT is strongly enhanced by a sufficient supply of workers with at least a college degree. Hence, investment in education represents one major building block not only for future innovation but also for technology diffusion.

In order to exploit the full potential of new technologies, no longer the specific skills with respect to a specific technology but the ability to learn and to reconfigure skills is essential. Generally speaking, diffusion and adoption of successive generations of technologies is enhanced if the initial investment in education takes the form of *general human capital* rather than (technology-) specific human capital. A significant stock of human capital which is only related to a specific generation of technology might give rise to technological lock-ins which prevent or retard the adoption of new technologies.

Moreover, *lifelong learning* is also crucial for technology diffusion. Governments should provide incentives for employers and employees to invest in education and re-training to prevent lock-ins and to keep the existing stock of human capital in line with the diffusion of new technologies.

**Improve management practices for technology diffusion**

The overall performance of most countries is determined not by the performance of its best managed companies, but by the size of its "tail" of poor performers. This means that management practices are essential for the efficient use of the labour force's competences and the opportunities generated by the adoption of new technologies. Empirical evidence shows that the diffusion of organisational innovations (e.g. management practices) is slower than the diffusion of new technologies. A recent international survey of management practices conducted by the London School of Economics and Political Science (LSE) indicated that, in comparison to EU firms, a larger share of US firms implements management practices which help to *adopt ICT effectively*. This advantage is especially prominent in human resource management practices – an area which is important for knowledge economies.

**Regard FDI as a mechanism for technology diffusion**

With respect to the improvement of management practices, *Foreign Direct Investment (FDI)* plays an important role in knowledge transfer .Foreign run companies can be a driving force for the regional adoption of international best management practices.

Moreover, competition significantly stimulates the adoption of such practices. By developing environments that promote best management practices across all firms and by paying as much attention to the laggards as to the leaders in the business sector, governments can drive the competitiveness of their entire economies.

**How can technology laggards in the European Research Area be advanced?**

The welfare generated by new products, processes and technologies results mainly from their widespread adoption throughout the economy. A significant share of the associated costs refers to development and early adoption stages. This raises the question as to whether strong R&D performance is necessary for the broad diffusion of new technologies. The vast majority of firms will never undertake R&D but adopt new technologies by investing in capital goods, learning from others, etc. This free-riding seems to be a useful strategy for technology laggards at first sight. However, a free-rider policy that only emphasises the adoption of technologies developed in other countries will not be effective without significant national R&D. This is because countries need an absorptive capacity to adopt new technologies. In the case of General Purpose Technologies this is especially true i.e. new technologies that affect the entire economy such as ICT, where co-inventions and modifications are needed to realise the full potential of the technology. Hence, innovation policies and diffusion policies are rather complements than substitutes. Both policies can be justified on the basis that they address market failures such as imperfect information, market structures, and externalities. Despite this, diffusion policies are far less common than R&D policies.

Diffusion policies stress the importance of creating an infrastructure which supports the rapid spread of awareness and knowledge of innovations. Such policies primarily address small and medium-sized enterprises (SMEs). Typical programs in this field should include the following:

- To provide consultancy services to SMEs in order to facilitate the adoption of specific technologies
- To encourage the formation of clusters of regional firms in order to facilitate the interchange of knowledge and ideas and to promote networking

The importance of R&D policies has already been underlined by the 3% target of the Lisbon strategy. However, for diffusion policies remains a further need for action for policy makers. Technology diffusion has particular relevance for technology laggards. As a first step, mutual learning may emerge from the evaluation of technology diffusion policies in the regions and the exchange of results.

# 6 - Catching-up Member States and the Knowledge Economy of the European Union

*Reinhilde Veugelers*[28] *and Mojmir Mrak*[29]

*The report assesses the performance of the so-called "Catching-up Member States" of the EU with respect to their transformation towards the knowledge economy. "Catching-Up Member States" are ten "new" MS and four former cohesion Member States Greece, Portugal, Spain and Ireland. The catching-up process does not follow a simple new Member States (MS) versus old Member States divide. Some new MS, especially Slovenia and the Czech Republic, are catching-up on the knowledge performance dimension and perform better than some of the former cohesion countries, like Portugal and Greece. The report suggests strengthening the research infrastructure in the catching-up countries in order to allow the growth of the knowledge economy in support of economic convergence.*

The Report (i) provides empirical evidence on economic and knowledge economy convergence of the "catching-up MS" inside the EU-27, (ii) analyses factors/drivers that are important in these processes, and (iii) discusses policy implications and proposes recommendations to support convergence of the "catching-up MS" towards the knowledge economy.

**Empirical evidence on economic and knowledge economy convergence of the "catching-up MS"**

Since the early 1990's, catching-up Member States of the EU have made significant progress in reducing their economic development gap vis-à-vis the EU average when measured by per capita GDP. As shown in the matrix, all but one "catching-up MS" (Portugal) have reduced the development gap towards the EU average. Four of the "catching-up MS" - Greece, Ireland, Spain and Slovenia - have closed or almost closed the gap. The three Baltic States and Slovakia have a longer time to go to close their more sizeable gap, but they have recorded high growth rates in the past. The slower pace of growth in Romania, Bulgaria, Poland and Hungary predicts a long time to catch-up.

---

28 Professor Reinhilde Veugelers is Professor of Economics at the University of Leuven, fellow of the think tank Bruegel, Brussels, and a former member of the Bureau of European Policy Advisers (BEPA) at the European Commission.

29 Professor Mojmir Mrak is Professor of Economics at the University of Ljubljana.

**Matrix of economic and knowledge economy convergence performance of "catching-up MS" -** *Time to catch-up to EU-27 average*

| GDP per capita / Innovation | Indefinite | Long | Medium | Short | Reached |
|---|---|---|---|---|---|
| **Indefinite** | | Romania, Bulgaria | Slovakia | | |
| **Long** | | Poland, Hungary | Latvia | | |
| **Medium** | Portugal | | Lithuania, Czech Republic | Greece | Spain |
| **Short** | | | Estonia | Slovenia | Ireland |
| **Reached** | | | | | |

Notes:

- *GDP per capita catching-up* is measured as the change in the gap in GDP per capita (in PPP) relative to EU-27.
- *Innovation catching-up* is measured as the change in the gap in innovation relative to EU-27.
- *Reached* implies the country is at or above EU-27 average in 2007; *Short*: less than 10 years for catching-up (extrapolating average annual growth rates from the past 93-07); *Long*: more than 30 years for catching-up. *Indefinite*: with given growth rates, no catching-up possible.
- *Former cohesion MS* are listed in the first line of the cell, *transition MS* in the second line.

For more information on how the matrix was composed, see Report.

In contrast to this overall positive real economic convergence, the performance of the "catching-up MS" with respect to their knowledge economy convergence, measured with the Innovation Performance Index, has been much slower. None of the catching-up countries has managed to close the gap with the EU-27 average. Ireland, Slovenia and Estonia are the three best placed countries at the end of the period, but are still at a considerable gap. Also Portugal and Lithuania have seen important advances in their knowledge economy catching-up, but still need a longer time to catch-up. The least successful MS in terms in knowledge economy catching-up are Poland, who made only marginal advancements, and Slovakia, Bulgaria and Romania, falling even further behind.

Linking knowledge economy catching-up to economic convergence suggests a positive correlation, but with considerable country specifics. Among the countries with a stronger innovation-growth nexus, Ireland stands out among the former cohesion countries, and Slovenia and Estonia among transition countries. But the strong economic growth performance of Slovakia and Romania, and also the more modest growth performance of Bulgaria, Poland and also Greece are not related to KE growth, as these countries have witnessed no catching-up on KE dimensions. This lack of a KE basis to their growth questions the sustainability of their economic convergence, particularly when these countries will move further on their economic development path.

An interesting off-diagonal case is Portugal. Although Portugal has managed to improve its innovation gap, it nevertheless has failed to translate this into real economic convergence. The improvement in innovation is mostly a public sector component, with scoring on business innovation performance remaining low.

Overall, the analysis seems to suggest that for several catching-up countries their path to convergence is not built on knowledge-based convergence, and for those countries where economic growth is innovation based, there are still considerable vulnerabilities to the development of a robust knowledge-based economy. In particular, there is a concentration of economic and creative capacity in just a few sectors. Also their dependence on foreign markets, foreign investors and foreign know-how sources make their innovation-growth process more vulnerable, as the current crisis has made clear. The empirical evidence further suggests that the knowledge economy catching-up process does not follow a simple "old" – "new" MS divide. Some transition MS, especially Slovenia and Czech Republic, have made significant advancement in reducing the knowledge economy gap and have outperformed in this respect some of the former cohesion countries, like Greece.

**Factors and drivers of knowledge economy convergence of the "catching-up MS"**

Although there is a positive correlation between innovation and economic growth for all EU countries, the evidence shows there are important country to country heterogeneity in the innovation-growth link. To explain these differences, flanking conditions shaping the adaptive and innovative capacity of catching-up countries need to be factored in. The key flanking conditions for establishing a successful knowledge-for-growth nexus, particularly those relevant for catching-up countries, are identified as follows:

- Institutional quality, financial market sophistication and macro-economic stability,
- Well functioning local product markets,
- International openness through foreign trade and FDI,
- Absorption of new technologies and ICT availability and use,
- Education and human resource development, such as secondary & tertiary enrolment, quality of education and training, and
- Innovation capacity drivers, such as availability of scientists, quality of the public research institutes, university-industry links, venture capital availability, IPR protection.

Analysing the empirical evidence on catching-up MS's scoring on these flanking conditions suggests that despite large variations between "catching-up MS", countries situated at the bottom ranking of a knowledge-based economic catching-up, (such as Bulgaria and Romania among the transition countries and Greece among former cohesion countries) score on average low on most flanking conditions. Similarly, the better performing countries, like Ireland, Estonia, Czech Republic and Slovenia typically have a good scoring on all or most of the indicators reviewed. The evidence from Portugal and Hungary suggests that doing well on some flanking indicators, but not on others, is not likely to lead to an overall good performance. All this indicates that systemic performance on all flanking conditions is needed for successful knowledge-based catching-up.

For the “catching-up MS” covered in the Report, there are a number of specific issues that have influenced the process of reducing the knowledge economy gap. First, a number of these MS have gone through a process of transition. Secondly, all the “catching-up MS” have undergone at different times the process of accession to the EU. The EU integration process has influenced and continues to influence the knowledge economy catching-up process of newcomers into the EU by

- a continued commitment of new members to the reform process through transposition of the “acquis” and implementation of Lisbon strategy objectives;
- support from the EU budget, through pre-accession funds in the period prior to accession and through structural actions funds and other funding sources in the period of full membership of these countries and
- integration of new MS into the single European market.

Experiences show that the transition and EU accession process with clear commitments and precisely determined time-tables have contributed significantly towards speeding up reforms improving flanking conditions for an innovation-growth nexus, although progress achieved has varied not only across individual MS but also across different areas.

**Policies aimed at strengthening knowledge economy convergence of the “catching-up MS”**

Experience from the countries whose catching-up process has been the most innovation-based and successful indicates that systemic performance on all flanking conditions for an innovation-growth nexus is needed. Consequently, improving the knowledge-based content of catching-up for lagging countries requires a *systemic policy approach* addressing gaps on all flanking conditions, but especially so for those reforms needed to incite the private sector to adopt and create new technologies. Which mix of flanking conditions is to be encouraged by an individual country depends on the level of its development? Countries with large gaps will need to focus on those drivers that are particularly important for improving technology absorption while more advanced catching up MS will have to start putting more efforts on how to sustain productivity growth through own innovations. Addressing the catching-up countries’ vulnerability requires having the critical flanking conditions to develop a broader *domestic* capacity, promoting *local* spillovers and *local* absorptive and creative capacity. To this end, reforms aimed at improving (product and financial) market functioning are crucial, particularly as these are pivotal for structural change towards new areas of domestic strongholds. This is even more the case in the current crisis. With weaker financial markets and downturns in the economic cycle, new local innovators, who are pivotal “change” actors, are especially at risk, due to the low availability of credit.

Most of the competences and responsibilities for the design and implementation of appropriate policies needed to support the knowledge-based catching-up process are found at Member State level. But at the EU level there are some important policy levers which can complement Member State policies.

The major EU policy instrument for stimulating knowledge-based growth is the Lisbon Strategy, later relabelled as Growth & Jobs Strategy. When dealing with the idiosyncrasies of catching-up countries and improving convergence and cohesion inside the EU, a number of amendments should be made to the Lisbon strategy. As far as the governance of the Strategy is concerned, it should include improvements in the Commission's process of National Reform Programs' evaluations through an improved methodology for assessing these programs, taking into account catching-up specifics, and through more systematic benchmarking among catching-up countries and peer pressure.

Although implementation of the Lisbon strategy agenda is primarily the responsibility of MS and is consequently financed largely from national funds, the EU budget can also represent an important source of funding for knowledge-for-growth investments in the catching-up MS, particularly in the current crisis. The EU budget review currently under way and the forthcoming EU budget negotiations for the post-2013 period will be crucial for the success of the post-2010 Lisbon-type strategy of structural reforms in catching-up MS. The EU budget review should make a clear recommendation for a substantial increase of EU funding for knowledge economy measures. The review of the EU budget is also an opportunity to re-assess how EU budget funds should be allocated among the MS to support a knowledge-based growth in countries, taking into account their idiosyncracies. The trend of a growing share of Lisbon-type expenditures in overall cohesion policy expenditures is a positive development and should be maintained.

The Report shows that there remains a long way to go for a knowledge-based catching-up process in the EU. Will the current crisis, which has hit all of the catching-up countries particularly hard, be a threat or an opportunity for these countries to re-adjust themselves during the crisis and to put themselves on track for a post-crisis recovery path that will be more knowledge-based? As a knowledge-based development path provides a better capacity to adapt to global, changing, volatile environments, the more a country's development path is knowledge-based, the more sustainable this path will be in future. Whilst the longer term benefits of this strategy are clear, the question in the short-term is whether the investments needed now (both public and private) can be found in the current crisis. The Report hopes to contribute to a better case being made for such investments.

# 7 - An Open, Integrated, and Competitive European Research Area Requires Policy and Institutional Reforms, and Better Governance and Coordination of S&T Policies

*Ramon Marimon*[30] *and Maria de Graça Carvalho*[31]

It is recognized that strengthening and implementing EU-wide R&D policies is a core instrument for the full development of the Lisbon Agenda, but why should we have EU-wide R&D policies beyond those of national and regional Governments? One argument is that transnational cooperation in R&D programmes and infrastructures are a stimulus for European competiveness in the Global Knowledge Society[32], however, *"the main rationale for EU-wide R&D policies is based on the need to develop an Open, Integrated, and Competitive European Research Area."* Only within such an ERA can transnational cooperation achieve its full potential and - more importantly – can all European regions find their competitive advantage through a process of 'smart specialisation'[33]. However, to consolidate such an ERA, *"better governance and coordination of S&T policies are needed"*.

'Smart specialisation' in the Global Knowledge Society is not achieved through a clever foresight-political process, but by letting Ideas, Innovations, and Researchers *compete without barriers, in a large, open and fair field,* as the ERA can be. The ERA is now an incredibly vast field, extending beyond EU borders, yet unfortunately national or regional boundaries and regulations often define the extent to which Ideas, Innovations and Researchers compete. The ERA not only needs to be Open with respect to the outside world (becoming an area of attraction for researchers, innovative firms and R&D investments), but must be "Open within" otherwise it cannot be externally competitive.

A 'fair competitive field' means that there are institutions and rules that guarantee fair R&D competition, but it also means that each region within the ERA has its own fair chance to compete and to become competitive. In an *Integrated Research Area this goal can be achieved by* the emergence of strong R&D agglomerations combined with the development of a decentralized R&D and Higher Education base of excellence across *all* European regions. Only with such a local base and non-local perspective, is regional 'smart specialisation' possible. Only then do pursuing 'excellence' and 'cohesion' become complementary objectives.

However, to guarantee an *Open, Integrated, and Competitive European Research Area* important policy and institutional reforms are still needed. Some of these reforms affect EU policies; others affect national or regional policies and institutions. Many of them have already been mentioned in the context of 'the ERA Green Paper' and its subsequent

---

[30] Professor at European University Institute, Florence and Universitat Pompeu Fabra - CREi.

[31] Bureau of European Policy Advisers, European Commission; since June 2009 Member of European Parliament.

[32] In fact, on the initiative of the EC, the EU is playing a leading role in 'Global Infrastructures and Initiatives' (e.g. ITER, Global Warming).

[33] "Smart specialisation in a truly integrated research area is the key to attracting more R&D to Europe" argues the Knowledge Economists' Policy Brief n° 1, October 2007, by Dominique Foray and Bart Van Ark.

discussions. We want to emphasize, at the EU level, the importance of having a proper legal framework for setting up competitive European transnational R&D institutions, working with financial rules based on trust and proper S&T evaluation; at the national and regional level, the need for reforms of public Universities and other Research Performing Organizations[34]. These reforms are necessary preconditions, but better governance and coordination of S&T polices are also needed.

In order to achieve the Lisbon objectives, two main weaknesses in the current EU R&D and Innovation public governance structure must be addressed. First, most R&D public funds are in the hands of national and regional governments, and while this shows the commitment of national and regional governments to 'build local R&D capacities', this goal is often not pursued with an Open and Competitive ERA perspective, which results in fragmentation, weak competition and, possibly, 'distorted specialisation'. Second, the 'complexity' of EU funding (EU financial rules, existing instruments for policy coordination and cooperation, etc.) often acts as a deterrent for scientists and innovative firms, and limits both the leverage capacity of the EU R&D policies, and the ability of the EC to lead intergovernmental initiatives.

To confront these weaknesses and reinforce R&D governance, at all its levels, one must take into account the fact that R&D funding institutions – as is the case with financial institutions – can only operate efficiently if they build up a good reputation, if they are 'trusted' in how they handle public resources and, more specifically, in how they handle the competitive and selection processes determining the allocation of these resources. Some organizational principles that help to build up 'trust' are: *i*) independence between the political authority (which may set social priorities and budgets) and 'funding managers' implementing the competitive and evaluation processes; *ii*) independence between 'funding managers' and those who may receive the funding; *iii*) a professional, stable and properly accountable organization, otherwise reputation can not be built; *iv*) clear, and well known, rules for evaluation criteria and selection procedures, and *v*) simple and timely implementation.

Based on the main objective of developing an *Open, Integrated, and Competitive European Research Area*, and on the above 'principles of trust and delegation', we make the following recommendations:

- National or regional governments (and their funding agencies), should not only operate according to the above 'principles of trust' (some already do, others require reform), but should also operate according to the above ERA perspective, e.g. removing effective barriers to Open EU Competitions and taking advantage of EU evaluation capacities[35], even if research has to be carried out locally.

- EU institutions, such as the ERC (founded on the above 'principles of trust'), should be open to, and capable of, providing service to national and regional governments, and should design policies and programmes which can have a multiplicative, *leveraged*, effect on national and regional policies[36].

---

34 See, for example, "Report of the ERA Expert Group on: 'Strengthening research institutions with a focus on university-based research'", January 2008.

35 In fact, at the local level the 'independence principles' (i & ii) are often too problematic to guarantee an effective ERA competition.

36 ERA-NET+, where the EC provides additional funding to joint calls for specific R&D funding set by a number of national agencies, is a step in this direction. Another initiative in this direction, that will help the

- While flexible coordination/cooperation may be the dominant mode in supporting R&D initiatives (in order to properly internalize economies of scale and scope, and knowledge spillovers), the experience in intergovernmental programmes (e.g. Eureka, ERA-Net, Article 169, etc.) shows the inherent complexity of intergovernmental governance, and suggests a different method of flexible cooperation: *to limit the intergovernmental intervention, and the EC leadership, to their policy role of setting and coordinating priorities, programmes and budgets, while delegating the evaluation, selection and management processes to 'autonomous EU funding agencies,'* based on the above 'principles of trust.'

- The current EU (EC) governance structure must be simplified and reinforced. Two alternative paths can be followed: *a)* to reform existing institutions according to the above criteria (e.g. strengthen EC as a 'funding agency'); *b)* to create new 'autonomous EU funding agencies,' to which EC and intergovernmental programmes can be delegated (consistently with 3).

The current trend of 'outsourcing EC management competences' seems to reflect that the first alternative is neither advisable nor feasible. However, the second alternative, which we recommend, requires EU political commitment and careful implementation in establishing the governance and accountability of the agencies. Furthermore, one should avoid dismantling existing human capacities, but should not create another institutional layer without simplifying the current structure; one should neither concentrate all of the 'EU evaluation and funding' capacities in a unique agency (which may damage competition), nor disseminate such capacities in an ad-hoc proliferation of shareholder-agencies (which will never create 'competitive trust').[37]

In summary, with FP7 the ERA is starting to have a better governance structure, but - aside from the ERC - the current 'diversity and complexity' – even if natural in the EU landscape – is a major deterrent to proper competitive participation by the scientific and technological communities. Governance, through proper EU delegation, must be improved, but the institutional engineering of the ERA cannot replace the urgent need for coordinated reforms at national and regional levels, so as to guarantee the development of an *Open, Integrated, and Competitive European Research Area!*

---

ERA, is the collaboration of the ERC with national and regional agencies, according to which these agencies (on a voluntary/flexible basis) fund researchers (possibly, working in their country or region) who pass the ERC standards of excellence, but cannot be funded with the limited ERC funds.

[37] While the EC DG has started an interesting process of creating 'Executive R&D Agencies,' it still seems limited in scope (recall recommendation 2) and, in particular, other forms of 'outsourcing EC competences', such as the Joint Technology Initiatives, raise the concern of the 'blurring between funding and spending' and of ad-hoc proliferation.

# 8 - How the Universities Can Best Contribute to Enhancing Europe's Innovative Performance?

*Paul A David*[38] *and Stan Metcalfe*[39]

*European universities vary widely, in their financing, governance, research/teaching balance and interaction with businesses. These interactions with other organisations are important in forming "knowledge ecologies" from which emerge "systems of innovation." Public policy-makers and university leaders must avoid confusing research and invention with innovation. Research discoveries and inventions certainly are needed to sustain innovation, yet universities are organisations with specialized capabilities and cannot exert effective influence upon many critical conditions -- financing, regulations, macroeconomic and fiscal policies affecting business investment demand – that govern the vitality of a region's "innovation systems." While stronger inter-connections between universities and businesses are to be encouraged, care must be taken in developing them to suit the particular circumstances of the participating organisations. Generally, the principal source of academic knowledge transfers supporting business innovation remains the flow of university-trained graduates – including scientists and engineers. Patent licensing can be a useful transfer channel, but experience in the US shows that too much emphasis by universities on acquiring and exploiting intellectual property rights can hamper knowledge-sharing and collaborative research with the business sector, without solving research universities' collective funding needs.*

There are approximately 4000 higher education organisations across the EU and at least 600 other public research laboratories. Their activities are divided between applied and basic research and dissemination of that knowledge. Even though one label is generally used in referring to institutions of higher education – "universities"[40] –differences among the organisations lumped under that heading can be vast, in terms of their size, balance between of research and teaching, range of disciplines covered, extent of commitment to inter-disciplinary teaching and research, and international status. Moreover, the mix of institutions with different purposes and characteristics varies considerably among the regions of the European Research Area (ERA).

The research universities (among other public research organisations) are a natural focus of attention when considering the EU's approach to knowledge generation and innovation. Several concerns have been raised in this context:

---

[38] Stanford University & The University of Oxford: pad@stanford.edu; paul.david@oii.ox.ac.uk

[39] Manchester Institute of Innovation Research, the University of Manchester, stan.metcalfe@manchester.ac.uk

[40] It is convenient – and now conventional usage (at least in European Commission documents) – to take "universities" education institutions such as the *grandes ecoles*, *Fachhochschulen*, *politecnicos*, and other, emerging technical research and training institutes, including the prospective European Institute of Technology (EIT).as a collective descriptor for tertiary educational organisations. We do so here without suggesting that in specific policy contexts one may safely disregard the important differences that exist between universities and other higher

- Are there enough EU universities at the forefront of international research to be able to provide EU firms and governments with the best and most relevant research findings?
- Do EU business firms have the capabilities need to grasp the research output of the region's university faculties and trainees, and so interact effectively with them in solving operations problems and developing innovations?
- Should there be specific organisations to connect universities and commercial firms and facilitate "knowledge transfers" among them?

This briefing focuses on the question: *How should European universities be contributing to the improvement of innovative performance by Europe's firms and the region's ability to compete successfully in the global marketplace?* There is a widespread view that the performance of the ensemble of European universities is not adequately responding to the challenges posed by the region's internal needs and the intensified competition in its global economic environment. Frequently mentioned reasons include lack of funding, insufficient coordination of national policies and initiatives, barriers to cooperation among institutions across Europe due to outmoded regulatory and governance systems, inadequate incentives for interactions with the business community, and excessive disciplinary specialization at the expense of relevant trans-disciplinary approaches in research and training.

There have been remarkable changes over the last 40 years that have created continuing pressures for organisational innovation and institutional adaptation within the European university sector. The developments of major significance here are:

- the general demise of centralized corporate R&D laboratories in manufacturing industry and the reorganisation of corporate R&D around divisional, near-to-market activities;
- the decline of defence R&D, as a result of the ending of the Cold War;
- the changed status of many public laboratories in research areas such as defence or metrology, that removed them from government – through privatization or other new forms of governance, and pushed them to search for other sources of funding;
- the increased internationalization of R&D activity (see Policy Brief 1), as large firms become more willing to engage with universities and technology research institutes on a world wide scale;
- the rise of "knowledge-based service" activities, increasing the importance of forms of "service sector R&D" that are quite different from the R&D traditionally performed in connection with manufacturing.

In short, current consensus of opinion among informed observers is that the institutions of the Community's higher education sector are in urgently need of "modernising" changes if they are to play their part in Europe's drive to sustain growth and job creation.

The present challenges arise on many fronts that have been well identified in the European Commission's Green Paper on the European Research Area.[41] Salient among them are: excellent and properly resourced research institutions that are able to develop and maintain partnerships with other entities, either through joint research ventures, clusters, or virtual networking; effective knowledge-transfers between public research and industry; forming a cadre of highly competent researchers who are mobile -- willing to move across institutional, disciplinary, sector and national boundaries.

---

41 See IP/07/469 or COM(2007)161.

Two other challenges may be added to the Commission's list. First, the diversity of specialised expertise within the university sector must be complemented by that in the business sector, requiring both improved information flows from research universities about relevant qualifications and talents of their trainees and, on the other side of the market, active demand from the private sector for such researchers and technical personnel. Second, the cooperative ethos of open knowledge-exchange, generally found among academic scientists, should be prominent among the driving forces in university-industry scientific research collaborations. That may require reconsidering the attention that Europe's universities give to efforts to commercialise knowledge gained by their faculties and research trainees.
To state the goals toward which the "modernising" of Europe's universities should be directed is much easier than to attain them. Bearing in mind their specialised capabilities and institutional constraints, how best can the research universities contribute to formation of an organisational ecology that generates sustained innovation?

An important point of departure in answering this question is that research and invention is not innovation; there is much more to the process of bringing new products and processes into commercial use than R&D, wherever it is performed. University-business linkages form only part of this process (albeit an important part) and their impacts on innovation are not independent of the many other factors that are at play.

It is hard to find an innovation policy document from government, business or university sources that does not call for greater, wider or deeper "interactions" between private business firms and the universities. The obvious and important question is *what is meant by interactions?*

The modes of connection between businesses and universities are many and varied and used in different ways at different times. They range from informal contacts, attendance at conferences and access to published literature, to recruitment of graduates, staff exchanges and joint research programmes or specific contracts. It is clear, however, that the principle connections that businesses value in the sphere of knowledge-based interactions with universities take the form of their employment of graduates, qualified scientists and technologists. Faced with information needs relating to existing operations and innovation, firms that turn to external knowledge sources are more likely to use their links with customers and suppliers then their contacts with academia.

Yet, in many discussions of universities' role in innovation processes, two very different and sometimes conflicting notions of "connections" or "interactions" with business are often lumped together. One conceptualisation looks toward the better connection of universities with firms' innovative activities, through stronger networking arrangements, collaborative funding of research programmes, and foresight activities in which scientific and technical experts participate.

The other sense of "connection" is about having universities better exploit the ideas developed within their precincts, through professional management of intellectual property, opening technology licensing offices and launching and investing in their own "spin-off" and "start-up" companies, and developing fee-charging consultancy services. This panoply of commercial activities is sometimes described as the "third" stream of university contribution to innovation, distinguishing it from the two traditional "streams" of fundamental research and training.

While the first of these concepts of "connection" respects the division of labour between academia and commerce, the second seeks to transform it by bringing higher educational institutions more fully into market as a supplier of innovation services. This contrast opens much room for debates about the virtues or vices of each conceptualization, but, *the practical policy issues concern the balance that should be struck between universities' engagements in these two kinds of interactions with business.*

Approaching this question calls for a proper understanding not only of the benefits, but also of the costs. By pursuing the commercialisation connections with innovation, it is quite possible that universities will sacrifice the individual and systemic gains that would come from forging closer cooperative interactions with firms, based on mutual advantages of research collaboration and personal networks of knowledge exchange.

Further, even though some universities can enter the business of innovation and succeed in competition players from industry, to acquire and maintain those capabilities requires attention and problem-solving efforts academic leaders that may come at the expense of responding to new challenges in fulfilling the institution's two traditional social missions.

Strong reinforcement has been given by national governments and the EC to European universities' initiatives in obtaining and exploiting patent rights as a means of commercialising the research findings of their faculties. In a significance sense Europe has been following a path pioneered in the U.S. since 1980.[42] But there is growing recognition in U.S. corporate and innovation policy circles that the right balance between the two kinds of university-business knowledge-transfer interactions has not been found there; that the pendulum has swung too far toward university research commercialisation based on intellectual property rights. This has been reflected recently in the recently announced Open Collaborative Research Program, under which I.B.M., Hewlett-Packard, Intel, and Cisco Systems and seven U.S. universities have agreed to embark on a series of collaborative software research undertakings in areas such as privacy, security and medical decision-making, under terms that commit all the parties to making their research results freely and publicly available.

The longer term consequence of effective university reform is likely to be a more refined division of labour within the research system, with a clear recognition that different models of a modern university are possible: interactions with the business sector won't conform to "one-size-fits-all" prescriptions, and *a combination of incentives and liberalised regulations will permit differentiated institutions to adopt different modes of governance that will enable them to compete for varied sources of funding*.

[42] The Bayh-Dole Act [passed in 1980 as Pub. Law No. 96-517, Section 6(a) 3015, 3019-28, and codified as amended as 34 U.S.C. Sections 200-212 (1994)] simplified and codified the terms on which higher educational institutions conducting federally sponsored research could seek intellectual property rights in the results.

# *PART C - BEYOND THE CRISES*

# 9 - "Whose Lessons to Be Learned?" Reflections on New Orientations in US and European Innovation Policies

*Bart van Ark*[43]

## A long haul to economic recovery

The current economic downturn has created challenges for advanced economies to continue increasing its living standards along a path of growth through innovation and knowledge creation. While the urgency for an innovation agenda has not changed, the economic context has changed the nature of the debate. Before the crisis the focus was on how Europe could improve its innovation performance relative to the United States. The U.S. seemed to have been more successful in turning its innovations into changed processes, new products and services and, as a result, faster economic growth, especially higher productivity growth. The R&D deficit in Europe relative to the U.S. was one of the factors of concern, but problems extended beyond that to the failure to create a truly common innovation space in Europe. Following the emergence of the economic downturn in 2008, and once the fiscal and monetary stimuli have ran their course to lift the economies out of the deepest holes, both the U.S. and Europe will be looking at innovation as the ultimate method to return to sustainable growth.
Unfortunately it is going to be a long haul, as neither Europe nor the U.S. will see an impressive recovery. Supply conditions seem to be lifting in both regions, but at best represent a “return to normalcy”. Due to the systemic nature of this crisis there is little scope for a significant increase in demand, be it domestic demand or exports to the rest of the world, catching up with supply any time soon. The current output gaps for individual countries are very large, which means that actual output levels are far below potential output levels, leaving huge amounts of underutilized capacity. It is not easy to estimate how long this will all take, but it could well be until 2020 before we have closed the output gap.

## Innovation dynamics are under pressure

In such situations there are seemingly few incentives for rapid innovation. However, the counter argument is that economic crises have historically shown to provide breeding grounds for economic renewal. “Never let a crisis go waste”, is a statement often heard, and this may also be true for the creation of new opportunities for innovation. But this is easier said than done.

Firstly, the constraints on the demand side of the economy, already mentioned, remove the main incentive for innovation, which is the existence of dynamic and sophisticated consumers and businesses. The lack of dynamic markets was already problem already in several European countries (notably in Germany) before the crisis, but has now become an issue across advanced economies. Secondly, the huge amount of underutilized capacity as a result

[43] *Vice-President and Chief Economist, The Conference Board,* Keynote Speech for Conference on “S&T policy in times of crisis: Prospects for the knowledge-based economy” at the European Commission, 25 June 2009, Brussels.

of the output gaps reduces incentives to innovate through investment in new machinery and equipment. Companies will stick with their current stock of machinery and reduce orders for the latest updates, etc. Thirdly, the long recovery path also poses risks beyond investment in tangible capital as it can also to an erosion of intangible capital. In particular the human capital of high skilled workers quickly erodes as worker training gets postponed. R&D programs are also coming under pressure as earnings fall and opportunities for the marketisation of new innovations decline. Finally as the systemic crisis in financial markets will take time to get resolved, it creates a constraint to easily accessible capital, in terms of quantity, cost and – important for innovation – quality of capital. Access to venture capital has been seriously hit, and will need to get back on line, in particular to fund R&D and innovation in small and medium-sized enterprises that cannot rely on retained earnings as large firms do.

What makes things worse is that already before the crisis, both Europe and the U.S. were on a downward trend in productivity growth. Europe has been on this path for two decades, but the U.S. also showed a slowing productivity performance from around 2003 – probably as a result of waning productivity effects from ICT production and use and lower demand effects as the rapid increase in consumption subsided. Barring unanticipated breakthroughs in science that will impact on the existing technological paradigms, current innovations are likely to represent small incremental steps with modest effects on productivity.

**Large strategic and policy challenges**

As a result of the crisis the strategic and policy challenges to support technological change and innovation are huge in the current economic environment. The depth and length of the recession has pushed many firms closer to the survival line. It has increased the pressure to focus on short term operational issues, notably cost-savings. The more medium tactical issues, such as improvement in performance and the development of new markets, or long term strategic issues like deeper reforms or attempts to achieve global leadership, are put on hold.

What we will see in the near future are some major changes in the business landscape, with many losers and many winners emerging in coming years. These changes provide an important dynamic to renewed growth and recovery – provided markets show greater dynamics on the demand side. At the same time, new competitors from emerging economies are changing the contours of the global business landscape as well.

Policy makers in advanced economies have a major task on their hands to provide a breeding ground for renewed organic growth. Policy instruments will need to focus not only on the closing the output gap in the short term, but also on strengthening potential output and productivity growth itself in the medium and longer term. The current fiscal stimulus plans cannot be the only or even the most effective tool for long term recovery. Part of the long term policy framework, in particular in Europe, will need to continue to focus on improvements in operational efficiency that is, narrowing of the gap between average and best practices among businesses by putting the emphasis on diffusion of technology and innovation practices. Many of the policy instruments to achieve this goal are not exclusively related to research and innovation policies, and need to be an integral part of a broader policy framework to be effective. Hence a renewed commitment to many aspects of the Lisbon agenda - to make the European economy more dynamic and competitive - is a likely element of a new growth agenda. Such an agenda should clearly go beyond the 3% R&D target, and put greater emphasis on diffusion of technology and innovation, schooling and training, market reforms (notably in services), etc..

The United States, while historically more successful than Europe in creating a dynamic growth environment that supports technology diffusion and innovation, is currently facing its own challenges to maintain a flexible labour market, to re-create capital markets for venture capital, and to invest in worker training and human capital. European and U.S. companies and governments could benefit from learning from each other in how to help companies to improve best practices.
It seems there is a particularly strong need to strengthen innovation in services industries. Here the U.S. has been especially successful, in part benefiting from supply sources, like a very efficient of ICT in services practices in retail, wholesale, finance and business services. But it seems the U.S. has also benefited from a strong and mature demand that has strengthened scale effects and the production of more sophisticated services. In Europe, innovations in services have not been easy to commercialize, and the failure to create a genuine single market for services has become the Achilles' heel of productivity growth in services. Innovation policies directed to diffusion need to concentrate on service industries, in addition to the more traditional models focused on hard innovations in industry.
In addition to strengthening the diffusion of innovation, the other policy approach to strengthen the growth environment is to focus on new strategic growth initiatives. This requires a policy framework which is explicitly geared towards the creation and use (commercial and non-commercial) of knowledge. Such knowledge areas, often identified as general purpose technologies (GPTs), require a comprehensive innovation strategy that involves government, business and society in creating demand and supply for research, development and applications.

The United States has traditionally been better in supporting and nurturing strategic innovation initiatives, and the new Obama administration has pledged to strengthen such initiatives in several areas, including environmental technology, biotechnology, ICT and combinations thereof. They have committed significant public investment in infrastructure, energy, science, and health. Some of these are complicated programs given the American political context. So the key to future success will be the ability to align government and business interests in the longer term, and to build an integrated network of regional innovation systems that involve education and knowledge institutions.
Europe does not have a lot of experience with specialization strategies in innovation, and where it tried in the past it has either been unsuccessful or it has, at best, been very costly. The concept of "smart specialization", as proposed by the "Knowledge for Growth" Expert Group and which builds on the concept of general purpose technologies, represents an original way for Europe to benefit from its scale and diversity to merge strategic innovation initiatives with an emphasis on diffusion and learning between leading and following regions and firms. It therefore essentially marries its (potential) strengths in diffusion with the need to build scale and create focus in knowledge creation. The smart specialization requires a broad commitment to diffusion strategies across European countries based on investment in R&D, human capital and other economic competencies.
Smart specialization strategies also require a broad commitment to continue to invest in the resource base of the economy. This resource base does not only consist of the traditional factors of production (labour and tangible capital) but also of strategic capital (intangibles) and financial capital. This type of capital, which includes ICT (software, databases, etc.), knowledge capital (R&D, patents, licenses, non-technological innovations in services) and economic competencies (worker training, organizational restructuring, brands, etc.), is key to a firm's strategic advantage and provides the backbone of any innovation strategy.
As the current and future (medium-term) economic environment will be characterized by continued underutilization of tangible capital and a potential threat of erosion in human,

knowledge and other intangible capital, the most urgent matter is to devise a European investment plan for innovation. It is here that the interests of government and business coincide and complement each other. It is also here where the strengthening supply (better inputs) and demand (more sophisticated customers) for innovation meet. Such an investment plan for innovation is a concrete step that can be taken as a follow up to the short term fiscal stimulus plans and that emphasize the role for innovation as the main driver for long term growth.

# 10 - Preparing for the Next, Very Long Crisis: Towards a 'Cool' Science and Technology Policy Agenda - For a Globally Warming Economy

*Paul A. David*[44]

The motivation for this short presentation on a very big subject is a worry – a worry that the present economic crisis is likely to contribute to the already-existing temptations of governmental and private actors alike to behave in a time-inconsistent fashion when responding to the challenge of climate change. The specific concern here is that science and technology research commitments be launched soon enough on the scale that is likely to be needed, and that timely steps be taken toward the supportive adaptations in long-standing institutional and regulatory readjustments that can render those investments in knowledge more effective.

Given the numerous serious but essentially transient occasions on which the attention of governments is susceptible to being deflected from dealing with chronic economic problems, it is hardly too early, and now risks being too late for major actions that would have payoffs in terms of affordable green house gas reductions two decades in the future, when they really will be needed. The world is confronted with a problem that simply is not "storable"; the challenge of global warming is one that grows in size and severity if counteraction is deferred, until it will reach a point of instability beyond with ameliorative measures will cease to be feasible. This really is different from the Y2K problem.

As obvious as that might seem, justification for continuing to call attention to it can be found in the halting progress toward coordinated international agreements to address climate change issues, and the recent indications that the effect of the current economic crisis --aside from some marginal influence on the allocation of expenditures scheduled by "stimulus" programs -- has tended to sap the policy momentum that had developed during 2006-2007 behind public R&D programs and institutional initiatives to expand the portfolio of affordable technological means of controlling global warning.

International negotiations about concerted actions among the leading industrial countries to reduce green-house gas (GHG) emissions are preceding slowly, and in many respects the initial "bargaining" stance taken by some important players, notably Japan and the US, has been a disappointment. Certainly, they have fallen far short of the EU Member Countries' endorsement (in December 2008) of the package of EC Directives designed to active its "20-20-20" renewable energy strategy: 20% reduction of green-house gas (GHG) emissions by 2020, and 20% of energy consumption from renewable sources. Indeed, Europe has gone farther by pledging a 30% reduction in GHG emissions if the UN negotiations that will be held in Copenhagen this coming December manage to arrive at a general agreement.

At this juncture however, perhaps as is only to be expected in the negotiations of this kind, there is scant sign that the economically advanced nations are preparing to address the specific calls by major developing countries, including China, India and Brazil. The latter's

[44] EcolePolytechnique & Telecom Paris Tech; UNU-MERIT (Maastricht); Stanford University <pad@stanford.edu>

initial position is that the wealthy countries should commit to make disproportionately larger emissions reductions, technology transfers and programs of financial aid not only for climate change infrastructure investments in the developing world, but also in compensation for restrains on further intensive exploitation of their coal and forest resources. Whatever will be the "bargained outcome" of the present efforts to put in place a successor to the expiring Kyoto Treaty, one can anticipate – and hope – that it will emerge as just a small and comparatively easily achieved step in the extended sequence of increasingly difficult negotiations which yielded an adequate collective response to the unfolding long-run crisis of climate change.

"A crisis" can be defined as a situation in which the need for decision and action is both apparent and urgent, but in which exactly what one should do remains uncertain and undecided. This would seem to characterize the present challenge of mobilizing the commitment and coordination of global resources necessary to stabilize green house gas (GHG) concentrations at 450-750 parts per million (ppm) – which the 2007 Report of the Intergovernmental Panel on Climate Change (IPCC) concluded would be sufficient to hold global warming at the level of 2 degrees centigrade. Nonetheless, it is possible to say in very broad outline what can and should be done.

We can identify three ways in which government can constructively respond to the "climate change crisis." One is by pricing the damages caused by GHG emissions, through "carbon tax" or "cap and trade" programs that introduce transferrable emissions licenses. This could induce individuals and firms to "internalize" the costs of the potential emissions-related damages resulting from their present operating routines and contemplated changes therein. Moreover, if the issuance of licenses were set so that they gave rise to binding constraints for a sufficiently large number of enterprises, the result at the margin would mimic the effects of regulatory emissions standards in raising incentives for private investment emission-reducing technologies.

It is important at the outset to notice that this approach – favoured among a wide consensus of economists – relies on the market the allocate resources used directly and indirectly in activities that result in GHG emissions, as well as in investments that will affect the future costs of reducing such emissions. The potential deficiencies of market processes in allocating resources when the good to be produced and distributed possess "public goods properties" are well known among academic economists, and reductions of GHG emissions un-contestably qualifies as global public goods. Further, tradable permissions to emit (on which a market is expected to put prices) are intangible assets, and there is today for regrettable reasons a far more widely shared perception the potentialities of unregulated markets for financial assets and derivatives to function badly. Viewed from these perspectives, the sanguine reception the has greeted government announcements that the first-line public response to the climate change crisis will be to rely upon a new market, and the absence of scepticism and precautionary attention to the institutional structure and regulation of emissions-permission markets, is really quite remarkable. This is not the occasion to further detail doubts on this score, but taking note of them should serve to further emphasize the likely importance of the two other items that appear on the thinking economist's "to-do list".

The second mode of response is through publicly funded research and development programs to stimulate the search for new knowledge, and novel combinations of existing knowledge to generate a broad portfolio of technologies that directly or indirectly could yield significant reductions in GHG emissions, This could be seen as a continuation of recommendations for “public business-as-usual” in the form of  or as calling for a rethinking about how best to both stimulate and direct the search for knowledge, its effective dissemination and application in technological innovations.

A third line of response is precautionary in a different sense, namely, undertaking and encouraging the development of technical and organizational expertise that will reduce the future costs of actions aimed a mitigating the disruption and damage that would ensue from the rise in GHG concentrations during the coming decades – during which it is likely that the struggle to stabilize them will not meet with complete successes. Here too there is a need for knowledge-portfolio widening and deepening, to which a differently focused category R&D programs can contribute by exploring the possibilities of reducing vulnerabilities of structures and people to “extreme weather”, including adaptive population redistribution and geo-engineering. Projects of this kind are highly context-sensitive, and call for close interaction and knowledge exchanges, and extensive feedbacks among solution providers and solution-users in a multiplicity of specific industrial and environmental setting.

Although 2007 and 2008 saw a salutary awakening of governmental and private sector attention to the long-term climate change “crisis”—notably in the EU, where it brought forward ambitious and far-reaching policy proposals such as the Economic Commission’s Strategic Energy Technology (SET) Plan [COM (2007) 723], it is quite evident that that relevant policy actions in both the public and private spheres will be subject to serious coordination and “time inconsistency” problems. Immediate social and economic, not to say political concerns always intrude and compete for the attention of public agencies; at each moment these distractions from “chronic problems” a special locus, demanding attention to this industry or that sector, to some provinces and social groups but not others; or they curtailing the abilities of governments dependent upon tax revenues to honour long-term programmatic commitments while meeting short-term public expenditure needs.

This is happening around us at the moment: the current financial and macroeconomic “crisis” has been serious enough to deflect attention from strategies that would address global warming through by means of sustained major public sector commitments of scientific and technologically research investment, and the adverse macroeconomic demand situation has compounded the difficulties of inducing business investment in appropriately “green” production and distribution facilities. What has become more attractive to the governments of the Member countries, and hence for the European Commission, are the variety of shorter-term tactics aimed at stimulating aggregate demand in ways that would implement already available technologies for “green” purposes: retro-fitting buildings for greater energy efficiency, supporting the automotive industry to increase production of low-CO2 vehicles using electric batteries and second generation bio-fuels, investment subsidies for grid infrastructures to create more integrated European markets for electricity current generated by wind- and water-turbines.

Without argument, it is desirable that this “low- hanging fruit” be quickly plucked; that “stimulus” funding and induced private sector investment be steered towards those form of employment-generation, rather than other projects where the social rates of return are not as high. Nevertheless, settling for these measures leaves un-addressed “the climate change crisis” – defined as the state of not knowing what eventually will be both necessary and practicable means to stabilize GHG concentrations at a level that will not melt the polar caps, and trigger a runaway process that will put large areas of the world’s developed and developing countries under water. It is generally agreed in scientifically and technically informed circles that to avert this will require the development and eventual global deployment of a range of technologies -- for energy supply and end-use, land-use, agriculture, and transportation support of adaptive population redistributions -- that either have still to reach the proto-type stage, or if they have done so, remain far from widespread commercial feasibility. For example, even in the field of electric vehicles, lithium-ion batteries for plug-in electric vehicles that would have a 40 mile range still cost about $10,000 apiece.

The precautionary principle argues against waiting for the needed breakthroughs to happen spontaneously, or for the private sector to step forward and gamble on the prospective profitability of owning the intellectual property on critical technologies to avert environmental catastrophes (especially not when it is likely that truly critical patents would become subject to compulsory licensing). Due weight therefore should be given in government climate change and energy strategies to the key potential benefit of undertaking major programs of focused scientific and technological research and development investment at this time, because they could dramatically reduce the costs of having drastically to restrict GHG emissions by other means in the future.

The commitments of global resources that one should envisage are really quite daunting. A back-of-the-envelop calculation may serve to underscore this, by starting from an estimate made for the McKinsey Global Institute [see Enkvist, Nauclér and Riese, in McKinsey Quarterly, 2008(2): pp.36-43] that the projected growth of global energy demand could be cut in half by an investment of $170 billion a year (earning a private internal rate of return of 10 percent per annum) in each of the 12 years from 2008 to 2020. But considerably more than a 50 percent cut in global energy use concentrated on GHG emitting sources would be required. The IPCC Report called for a reduction in annual GHG emissions from just under 50 billion tons in 2007 to 5-10 billion tons in 2050, an implied reduction of 80 to 90 percent. More recent studies suggest that that may be insufficient to stop the planet's temperature from rising above the 2 degrees centigrade level, because the initial simulations underestimated some of the positive feedback effects of transitional warming. (More heat-absorbing ground becomes exposed by the retreat of glaciers, the seas' will become less absorb CO2 , and, worse, climatic changes and polar ice sheets that break up and float into more temperate waters may disrupt the oceanic convex ion cycles and cause the release of gases that otherwise would remain compressed in the cold depths.)

If we therefore allow that the 50 percent cut in projected demand for carbon-fuel sourced energy – effecting a 40-45 billion ton reduction in GHG emission -- would still leave another equal cut in emissions to be achieved, this implies the need for a further, 100 percentage point reduction from the level achieved by the first $1.70 trillion worth of investment. To take into account the likelihood that the second equal volume reductions in GHG emissions will be more costly than the first, suppose that the investment requirements are proportional to the percentage reductions at each stage, so that the second step will cost twice the capital sum on the first step, or $3.40 trillion. The total bill, at $5.1 trillion is manageable, but nonetheless considerable: about 12 percent of 2008 global GDP, and almost 50 percent of global fixed investment expenditures in 2008 prices. While this can be spread out over more than a decade, the bulk of it probably would have to be concentrated within the coming decade and a half in order to have the capital formation in place by 2030.

What could be achieved by a successfully focused program of exploratory R&D investment – not considered, nor included the foregoing calculations based upon the MGI study – is the creation of technologies that would lower the investment costs of achieving the required GHG reductions, and make it rational to delay the most lumpy and irreversible of the capital formation commitments in order to preserve the option of implementing more efficient technologies when these emerged. But exploratory research is particularly uncertain, and risks therefore call for an early start with a diversified research portfolio from which the more promising lines can be selected for further development.

Viewed from that perspective, it is disappointing to observe the signs that the current macro-economic crisis has deflected the EC's focus, at least temporarily away from its SET Plan for Europe, in favour of emphasizing the near term approach of lowering the region's GHG emissions by establishing regulations and a market mechanism to price such emissions. As recently as November 3rd of last year, EU's Energy Commissioner, Andris Piebalgs, in a speech in London [EC SPEECH/08/573] was setting out the elements of "the Commission's vision for renewables" in terms of the role that a range of available technologies would play in achieving the "20-20-20" targets proposed by the Commission, and emphasizing the very modest costs that would be entailed in deploying biomass-using Combined Heat and Power installations, solar-, wind- and tidal-generation technologies for electricity, and second generation biofuels for the transport sector. The concluding point of his message was the affordability of the SET Plan's "package" for energy-intensive sectors, even in the current economic crisis. This was because provision had been made to use the revenues raised by the proposed Emissions Trading Scheme to compensate the carbon-fuel using sectors that were most affected by the pricing of GHG emissions. The thought that such compensation would work to offset the pressures on those firms to alter their production methods or energy sources, however, did not stop the Commissioner from concluding that "it is time to realize that we don't have a long-term choice about developing a low carbon economy. Climate change, vulnerability to high fossil fuel prices and energy security mean that we must not let current market turmoil distract us." Indeed, would that he had not already been distracted.

The passage of 6 months, and the deepening economic recession has only reinforced the shift of the Commission's focus away from science and technology policies as a key response to the challenge of climate change. May 24th-25th found the Energy Commissioner at the G8 Energy Ministerial Meeting in Rome, calling for a "good investment climate to take the energy sector out of the crisis." The press release reporting his speech mentions that the Commission also was "trying to increase to increase its efforts on research for technologies that will help reduce CO2 emissions, such as carbon capture and storage." [see http://europa.eu/rapid/pressReleasesAction.do/reference=IP/09/830], but Commissioner Pieblags' intervention in the working session devoted to Energy Strategies to Respond to Global Climate Change, stressed that "Our main tool to drive the energy sector toward a low carbon system is the price of CO2 in an open market." He therefore reminded the audience of "the importance of open and transparent markets in order to assure energy security, together with permanent dialog between producers and consumers in order to create the necessary climate to ensure investment in new generation capacity, infrastructures and the promotion of renewable energies and energy efficiency." The goal of encouraging investment in energy production is evidently stems from energy security concerns, and the virtue of the Emissions Trade Scheme appears from that perspective to consist in providing a source of subsidies to major energy-users that will help maintain European demand for the required increase in domestic energy generating capacity. Evidently, the GHG emissions reducing purpose of pricing the use of carbon fuels, and the need to sustain a good investment climate for R&D that would lower the costs of renewable energy sources, are being pushed from the centre of the energy policy stage and how long it will be before they regain it remains obscured in the uncertainties surrounding the timing of the recovery of aggregate demand in the European economy.

This situation is regrettable and fraught with potentially serious risks. The scale and complexity of the scientific and technological efforts that will be required warrant giving consideration to measures that would enhance the effectiveness of both public and private research investments and technology transfers in a wide array of “green technologies.” Beyond the needs for international coordination, and coordinated funding action on the part of governments at different levels, there would seem to be a good case to be made for raising the payoffs from R&D expenditures by avoiding excessive correlation of public and private research portfolio and consequent un-necessary duplication of domestic as well as international efforts. Perhaps in this pressing connection there is a compelling rationale for devising and implement agreements and focused funding for “smart specialization” in applied research and pre-market development of GHG emissions reducing projects on both sectoral and regional basis, venturing even beyond the “entrepreneurial discovery” policy approach that recently has been proposed as the mode through which to pursue “smart specialization” in research, development and training policies in the European Research Area [see Foray, David and Hall, EC-DG-Research K4G Brief No. 9 (June), 2009].

Furthermore, urgent attention should be given to a range of measures that could enhance the effectiveness of both public and private R&D investment in a wide array of “green technologies,” by facilitating knowledge-sharing, adaptation and diffusion of innovations. This would entail a critical rethinking of ways to mitigate the inhibiting effects on exploratory research and cumulative incremental technology development that arise from both long-standing and recently developed features of the intellectual property rights regime. Targeted domains for research exemptions, defined fields in which a combination of a liability approach to IPR infringement and greater reliance on prizes for inventions in defined fields supplements the existing property rights approach are one part of the agenda for careful consideration. But competition policy adjustments to permit efficient pooling of patent, copyright and database rights, and the exercise of existing governmental rights to use patents for public purposes without paying licensing fees, and to mandate compulsory licensing of such inventions to third parties also should claim attention under this se heading.

However radical the foregoing may be deemed to be in some quarters, these proposals for institutional adaptations and innovations to improve the efficiency of resource allocation in the production and distribution of useful knowledge hardly are new and most of them will be found to have been cogently elaborated by legal scholars and economists. If the challenge of the “climate change crisis” does not create a context warranting their receiving a serious hearing in forward-looking EU public policy deliberations, what would?

# 11 - Structuring a Policy Response to a "Grand Challenge"

*Dominique Foray*[45]

A few decades ago, Stigler pointed out the existence of "*the enormous conformity among economists doing policy research*" and this provocative statement can easily be extended to the particular domain of technology policy research.

In the field of science, technology and innovation, this conformity has been mainly due to the fact that, for the last three decades, the policy research agenda focused almost exclusively on the development of tools, instruments and programmes, aiming to increase the rate of innovation in the system. But beyond the infinite variations that the most sophisticated economists in this field have come up with regarding the question of the effectiveness of tools and instruments and the sensitivity of the system to various degrees of intervention and beyond also the real progress made by economists in identifying the centrality of the so-called "framework conditions", one big area remains relatively unexplored: the direction of innovation.

Now it is quite tempting to recall that the seminal book of our profession in 1962 (edited by Dick Nelson) was entitled "*The rate and the direction of inventive activities*". In this book, it was argued that a large fraction of R&D effort is at least partially divorced from the incentives and controls of the market and that issues regarding organizations and decisions related to this fraction of R&D needed to be addressed. This was in 1962; since then however the scope of the policy research agenda has been severely diminished.

Why is this the case? Whichever expressions we like to use – Washington Consensus or Chicago School – it is clear that the policy research agenda has been dominated and shaped by the strong claim in favour of a modest and *neutral* policy in the field of technology and innovation.

The arguments are as follows: yes, there are market failures, particularly in the area of R&D in the form of positive externalities (knowledge spillovers), which drive a wedge between private and social returns from R&D investment. Because of these positive externalities, some socially useful investments will not appear as being privately profitable, so the market will not sufficiently support the activities and policy needed to correct this failure. But the next argument is that government failures are expected to be greater than market failures (although there is little evidence as to how much greater they are). And so the main message relates to neutrality; the resources allocated through the policy mechanism must respond to market signals rather than bureaucratic directives. A good, tolerable and honourable policy does not select projects according to preferred fields but responds to demand that arises spontaneously from the industry. Departing from neutrality in order to influence the direction of innovation – providing subsidies to favoured firms or sectors - is always dangerous since it implies guessing future technological and market developments. This opens the door to all those little monsters that economists always try to eradicate, which they call wrong choices, picking winners, and market distortions.

---

[45] Chair of Economics of Innovation, College of Management at EPFL – Switzerland, and Vice-Chairman of the "Knowledge for Growth" Expert Group

In short the message was: "*don't undertake actions to influence the direction of innovation but let market prices reflect the future scarcity of commodities so that certain kinds of innovation will be induced by changes in relative prices*". There is obviously evidence of inducement – for instance some kind of correlation between energy prices and energy-related innovations can be found (Jaffe et al. 2004) – but in many cases the price system doesn't do the job (does not reflect future scarcity) and therefore has little effect on the direction of innovation. And when there are inducement effects, the timescale seems to be decades. So for policies that deal with prices, taxes and standards to have maximum impacts, long periods of time are required.

A nice example of how the (Washington) consensus about neutrality has been influential is this quotation from Nathan Rosenberg : "*in the context of activities that are immersed in a high degree of uncertainty, capitalism provides multiple sources of decision-making and initiative, as well as strong incentives for proceeding one step at a time. The notion that planning and centralization of decision-making are efficient is the opposite of the truth when there is a high degree of uncertainty and when goals and objectives cannot be clearly defined. One of the less-heralded but considerable virtues of competitive capitalism has been the speed with which firms have unsentimentally cut their losses as it became apparent that a particular direction of research was unlikely to prove fruitful. Where funds come from the public sector, by contrast, monies are likely to be spent much longer on unpromising avenues*" (1992).

This is a beautiful statement but one that is unsupported by empirical evidence: do firms cut their losses by abandoning major R&D projects more quickly than is the case in public R&D? In the most recent literature on corporate R&D, there is a growing theme which addresses the question of how to weaken the resistance of R&D managers towards abandoning projects that their labs had initiated, underlining the fact that there is also a problem within the business sector! Actually we do not know in which kind of institutional setting this inertia is greater!

So, the last three decades have been dominated in policy research and discussion by the argument that market failures need to be corrected in order to reach the desirable level of investments, but where these investments should go should not be a concern for policies. It is much better to leave this issue to the magical chaos of the "blind watchmaker". Any notion of specialisation policy or top-down strategic initiatives has become a taboo in policy discussion, particularly in the large international policy forums as well as in the Commission.

But we are now entering the era of crises and grand challenges – climate change, food, water, and health. These grand challenges make a good case for revisiting this debate. Increasing the rate of innovation is not enough; we do not necessarily want to increase the rate *randomly* in the system but in certain domains and sectors such as climate change or health - such areas where the centrality of R&D is emerging as a solution to structural problems. So the obvious argument today is that to cope with these major challenges and risks, it is not enough to proceed as usual with the neutral allocation of R&D subsidies, tax credit, framework conditions as well as an effective patent policy. There is, indeed, a need to accelerate the rate of advancing knowledge and implementing solutions *but in certain directions*. Clearly we are entering a new era for innovation policy where the deployment of new instruments is needed to acquire a better command and control of the directions of inventive activities.

### Defining the problem

However, we cannot address these issues as if the Washington Consensus had never existed. We cannot ignore the fact that government failures do exist, although we have relatively little knowledge concerning the net cost of these government failures. And so this is all about a new generation of policy, instruments and programmes, involving innovative design. How to make these policies aimed at influencing the direction of technical changes less vulnerable to government failures, wrong choices, market distortions?

We cannot merely copy and paste the old "mission-oriented" policy processes of the 80s. Indeed most of these programmes have been detrimental to what has been recognized more recently as an extraordinary booster for innovation: entrepreneurship, the competitive entry of young radical innovators (Veugelers, 2009). Thus the central question is how to make top-down initiatives favouring some fields (for instance to address climate change) and market-driven resource allocation logic allowing for "multiple decentralised experiments" compatible?

There is a certain atmosphere generated by frenetic innovators exposed to high-powered incentives that we do not want to lose by building a grand programme. The first generation of top-down policies was detrimental to the historical creativity of capitalism as an institutional mechanism to encourage innovation in a context of centrality and pervasiveness of uncertainty. They were detrimental to the specific ways in which decentralised markets approach the risks associated with the search for new technologies.

The main challenge is therefore to create positive expectations for multiple and diversified agents with regard to some fields while not attempting to impose predefined technologies, freezing or petrifying competition and finally dissipating the extraordinary power of a free market economy in boosting large numbers of experiments in a decentralised way – a system where innovations can occur everywhere.

### No policy response to a grand challenge without broad political consensus

The idea of a "Grand Challenge"(GC) is that some societal needs, involving complex and multi-disciplinary issues, do require the concentration of research resources and capacities in some predefined fields and areas of knowledge exploration and exploitation.

One important condition for the success of policy addressing a GC is its ability to shift resources to more productive use whenever possible, that is to influence not only the rate but also the direction of technical change. This condition implies a non-neutral allocation process with respect to areas for focus and sectors.

One obvious condition for launching this kind of policy with a reasonable probability of success in terms of concentration of resources and prioritisation is to base the policy response on a broad political consensus. This is the price to pay for developing and implementing a non-neutral policy. As David C. Mowery (2006) forcefully argues: US government success in "funding the ICTs revolution" was based on a large consensus that this field was a high priority government mission (national security) and conversely the US has repeatedly failed in energy R&D programmes because of the lack of any strong link between R&D public spending in this area and government mission with broad political support.

So no grand challenge will be translated into the formation of a coalition of countries and other stakeholders committed to significant public and private R&D effort unless a broad political consensus is reached.

The good news is that after the wars "against communism and against cancer" as effective mechanisms for mobilising abundant resources toward R&D, the case for large programmes in the area of environment and energy is now stronger than ever. Most controversial discussions have been closed and we are now approaching a time of much broader political consensus regarding problems and solutions.

The environment and energy crisis is finally seen as the ultimate threat in the richest countries. Two additional features help to make a good case for environment and energy R&D and technologies being a very appealing target for large R&D programmes and strategic initiatives:

- first, there is an increasing awareness that R&D in these domains is becoming a central issue (Arrow et al. 2008; Klemperer, 2008; Rosenberg, 2005; Stern, 2006); and
- second, the areas of business activities related to environment and energy are starting to represent an attractive source of entrepreneurial opportunities: market forecasts show that global demand for clean technology and environmentally friendly technology is likely to boom over the next decades.

**Structuring a policy response to a "Grand Challenge"**

Based on a shared vision and consensus, what do we want to achieve? Not really the invention of a new helicopter, or travel to the moon. The goal is *rather to promote a large area of "climate change-ameliorating innovations (health - or water supply - or nutrition)" where the EU can develop a comparative advantage*. That is the definition of what we want to see.

So the problem is not so much one of selecting the right technology - a very complicated problem, as emphasised by the works of Paul David and Robin Cowan - but making such activities (like "climate change-ameliorating innovations") as profitable as possible so that competitive entry (entrepreneurships) and intrapreneurial activities will occur. The main goal therefore is to increase the rate of return on R&D in the particular fields through a concerted set of actions in order to generate positive responses from the private sector.

In what sense is a policy addressing a GC different from a classic policy that is designed to address chronic underinvestment in R&D on decentralised markets? In the latter case, the main goal is to increase the rate of technical change while in the former the goal is to influence *both the rate AND the direction of technical changes*. The first generation of "mission-oriented policies" designed in the 80s paid no heed to the rate and mainly emphasised "direction" and the policy of the last three decades concentrated only on the rate. The challenge today is to care about the rate in a certain direction.

Some good documentation about federal US policies that were quite successful in preparing (and advancing knowledge toward) the Internet revolution is useful here (Mowery and Simcoe, 2002; Blumenthal, 1998). Such policies involved a set of concerted and (loosely) coordinated actions on both the supply and the demand side of a broadly predefined agenda (concerning electrical engineering, computing science, and information and communication technologies):

- to create and expand the required "knowledge infrastructure" (human capital, science, technology and engineering capabilities);
- to induce the private sector to respond positively to government policy by making the new domain as attractive as possible to for-profit organisations;
- to encourage the creation of a market for the new technologies through public procurement and adoption policies.

*Knowledge infrastructure: science and research policy*

When analysing the reasons for the success of the Internet revolution in the US, experts frequently overlook decades of federal expenditures through the Department of Defense and other agencies to develop the knowledge infrastructure and human capital. A central component of any response to a GC is therefore building the fundamental capacity to perform research in the future. This includes steps to promote training of scientists and engineers, rejuvenate laboratory capabilities in universities and other public research organisations, and establish programmes to disseminate research information for example through internships, postdoctoral fellowships and exchange programmes, both intra-European and between Europe and the rest of the world. The generation of an adequate supply of knowledge, ideas and instruments as well as highly skilled people and receptive universities for collaboration and problem-solving activities constitutes a central pillar of any structured response to a grand challenge. Even a generous programme of R&D subsidies offered to private companies will fail to produce more innovation and faster growth if the knowledge infrastructure fails to provide an adequate supply of the various knowledge assets. Without an abundant supply of basic knowledge, human capital and academic collaborations, private investors in this area are at risk.

Government R&D policy should also encourage more risk-taking and tolerate failures that could provide valuable information. This can be accomplished by adopting parallel project funding and management strategies and by shifting the mix of R&D investment towards more exploratory R&D characterized by greater uncertainty in the distribution of project payoffs.

Is it also necessary to stress the importance of the accessibility of the research infrastructure to all kinds of firms and of the dissemination of technical information to academic and industrial audiences?

Not only is the promotion of scientific capabilities important, but also the development of engineering capabilities: the willingness of private industry to commit financial resources to scientific research is considerably increased by the progress of the appropriate engineering disciplines. Strong engineering capabilities are also a mechanism to ensure that endogeneity kicks in, i.e. to make universities fully responsive to the technological and scientific needs of industry in the GC-related areas of R&D.

*Business R&D and innovation – policies to support decentralized experiments*

The private sector is expected to respond to incentives created by public policies if innovative activities in the prioritised area promise very high private returns. This is therefore a matter of i) creating special incentives to go into the field selected; ii) deploying the generic institutions and incentives to support an economy of start-ups, fast movers and new industries; and iii) stimulating the various markets associated with the selected field.

The policy actions corresponding to item i) involve what has been described in the previous sub-section concerning building the knowledge infrastructure and the human capital of adequate quality and quantity for the special needs of R&D and innovation in the field selected. They also include any kind of subsidies (or tax credits) aimed at increasing private R&D returns. Such support should be available to all firms exhibiting the wish to develop innovations that are in line with the GC objectives (for instance, climate change amelioration goals).

The policy actions corresponding to item ii) obviously involve the design and provision of tailored financing solutions to emerging firms; the design of mechanisms to facilitate competitive entry into new industries and services (lowering the cost of creation of new firms and the cost of growing from new to competitively established firms); the creation of a cost-effective patent system; the increase of institutional flexibility in labour markets to minimise the cost of innovation when defined in the Schumpeterian sense as involving 'creative destruction'.

It is also obvious that the private sector will respond to the incentives created by public policies only insofar as the policies are perceived as being credible, durable and reasonably stable.

The policy actions corresponding to item iii) are addressed in the next subparagraph.

*Demand-side policies*

Public policies supporting innovations have proven especially effective when funding for R&D was combined with complementary policies supporting the adoption of innovation. It is likely that the demand-side policies are central to influencing the direction of inventive activities.

As noted in a recent paper by Mowery (2009), the presence or absence of complementary procurement policies is an important factor mediating the economic effects of strategic/mission-oriented programmes. Many of the widely cited "spin-off" benefits of post-war US defence-related R&D spending have as much to do with the scale and structure of the procurement programmes that accompanied them as with the structure of the R&D programmes themselves. The lack of such procurement programmes in other mission areas, such as energy, has arguably reduced the effectiveness of US mission-oriented R&D programmes in those fields.

In the area of climate change, the improvement in the energy efficiency of public sector building and transport systems is a good example of an important area of R&D investment that can generate near-term business innovation and private expenditures if the market for application is initially subsidized by public policy measures (David, this volume).

*Managing the usual dilemma of top-down policies*

We will not discuss here the famous dilemma vividly expressed by David in terms of the "blind giant and narrow window" since one message of this paper is to let the market make the microscopic choices in terms of technologies and innovations. We will discuss some other dilemmas and the ways to approach them.

*Non-neutral policies, distortion and programme design*

A central question concerns "programme design": how to make these mission-oriented large programmes less vulnerable to government failures such as wrong choices, winner-picking and market distortions. In other words: how to make them compatible with market-driven resource allocation allowing for multiple decentralised experiments.

A first principle has already been identified: it is crucial to be non-neutral in identifying a very broad agenda while being neutral vis-à-vis specific applications. Mowery and Simcoe (2002) emphasized this point by analyzing federal policies with regard to the Internet: federal agencies always tried to avoid the pre-definition of technology architectures and design but rather allowed the market to discover the best technologies. "*Neutrality with respect to commercial applications*" proved to be a very wise policy principle of the US governmental agencies in contrast to the efforts of other governments, such as the French Minitel programme or Britain's national champion policy. Logically such a principle needs to be associated with another one : such programmes have to be designed in order to foster the entry of new firms into emerging industries - and not only to help the large firms already in place. These two fundamental principles clearly mean that top-down technology policy and competition policy need to be complementary and not antagonistic.

Other principles for mitigating distortions created by the provision of subsidies to favoured firms, industries, and other organised interests are quite straightforward: agency independence in providing grants, use of peer review with clear criteria for project selection, payment based on progress and outputs rather than cost recovery.

The best funding structure for attenuating the sort of problems identified above is probably one that is not coordinated by a central agency but involves several agencies with distinct yet overlapping agendas.

Strategic initiatives and top-down policies are important but the design of the principles of resource allocation is critical too. We think that being non-neutral in identifying a broad agenda is compatible and coherent with being neutral vis-à-vis specific applications. Let the market discover and select the best solutions for responding to a pre-identified GC.

*Coordination: from Grand Challenge to big push*

Organising the allocation of resources in this way will not necessarily produce the "big push" (Murphy et al., 1989). Generating a "big push" requires not only an understanding of the basic principles of coordination problems but also a detailed grasp of the externalities and the innovative complementarities involved so as to create incentives and allocate resources in the right "places" for maximising pecuniary externalities and leverage effects.

For example, since technological progress requires both R&D and learning, R&D programmes should not be planned in isolation from practical application. R&D may be required to make even a relatively well-developed technology suitable for particular applications, and attempts to make practical use of a technology may reveal points where additional R&D would be most productive (see Arrow et al., 2008).

*Knowledge dissemination and appropriation*

Enhancing the effectiveness of both public and private R&D investments in the selected areas requires intensive knowledge sharing and innovation adaptations and diffusion. This in turn should encourage critical rethinking of ways to mitigate the inhibiting effects on research and cumulative innovation of some of the new features of the intellectual property regimes (David, this volume). Indeed knowledge openness (defining a system of institutions and norms in which the principles of rapid disclosure of new knowledge are predominant) can be viewed as a mechanism generating economic efficiency. However, such a system might be detrimental to the development of entrepreneurial activities that rely on the effectiveness of patent and other IPRs as a means to capture the benefits of the innovations (Graham et al., 2009). The challenge of finding the appropriate degree of intellectual property protection is likely to be even more difficult in the policy context described here since it is crucial for policymakers to both enhance the effectiveness of R&D investments (through rapid dissemination) and incentivise young radical innovators and other firms to enter the new markets. One solution, as documented in Mowery and Simcoe regarding the US policy, is a policy shift toward commercialisation, when public R&D spending is overshadowed by business R&D investments and the incentives targeting entrepreneurship become central. But whatever institutional solution can be found, knowledge dissemination and appropriation confront policymakers here as everywhere with the perpetual quest for balance.

## Conclusion

Any R&D policy designed to address one of the global crises of our time (climate, energy, water, food, etc.) must activate a variety of instruments and mechanisms to create the needed knowledge infrastructure (human capital, science and engineering capabilities), encourage private sector expenditures through various kinds of incentives and demand-side initiatives and develop an EU comparative advantage in certain innovation areas (and thus meeting the grand challenge).

There is certainly a conflict between *the classic desirability of maintaining neutrality* in technological choices in order to mitigate the usual distortions created by the provision of subsidies to favoured firms and industries and *the need to influence not only the rate but also the direction of technical change*. One of the messages of this paper is that this conflict can be considerably diminished when each of these two needs is applied at the proper level of aggregation. Maintaining a large political consensus requires very broad interpretations in terms of what the priorities are, and which fields and issues should be addressed in terms of R&D and innovation. The definition of a grand challenge has to be made at a very macroscopic level - i.e. the objectives or challenges are "large-grained" - while the microscopic choices regarding the kind of "fine-grained" goods (technologies and innovation) to be developed should be left for markets to determine. So the consensus has to be not on specific technologies and designs but on broad societal needs and systemic problems.

Structuring a policy response to a GC effectively and efficiently requires a fine policy mix, involving non-neutrality at the very general level of the identification of the challenge (to build a broad political consensus) and neutrality at the more specific level of the selection of R&D priorities and technologies within the large scope of operation defined by the GC (to leave the market free to experiment and select). The second message is that such a policy response to a GC would prove valuable in two ways:

- by rapidly addressing the great socioeconomic and global problems; and
- by playing a contra-cyclical role during the current recession.

**References**


Arrow K., Cohen, L., David, P., Hahn, R., Kolstad, C., Lane, L., Montgomery, D., Nelson, R., Noll, R. and Smith A., *A statement on the appropriate role for R&D in climate policy*, AEI Center for Regulatory and market Studies, 2008

Blumenthal, M., "Federal Government Initiatives and the Foundations of the Information Technology Revolution, *American Economic Review*, vol.88, 2, 1998

David, P.A., Preparing for the next, very long crisis: towards a 'cool' science and technology policy agenda for globally warming economy, this volume

Graham, S., Merges, R., Samuelson, P and Sichelman, T., *High technology entrepreneurs and the patent system: results of the 2008 Berkeley Patent Survey*, 2009

Jaffe, A., Newell, R. and Stavins, R., "Technology policy for energy and the environment", *Innovation Policy and the Economy*, vol.4, 2004

Klemperer P., *What is the top priority on climate change?*, Oxford University, 2008

Mowery D.C., *Lessons from the history of federal policy for an Energy ARPA*, 2006

Mowery, D.C., "What does economic theory tell us about mission-oriented R&D?", in D.Foray, *The New Economics of Technology Policy*, Edward Elgar, 2009

Mowery D.C. and Simcoe T., "Is the Internet a US invention? An economic and technological history of computer networking", *Research Policy*, 31, 2002

Murphy, K., Shleifer A. and Vishny R., "Industrialization and the Big Push", The *Journal of Political Economy*, vol 97, 5, Oct.1989

Rosenberg, N., "Economic Experiments", *Industrial and Corporate Change*, vol.1, 1 1992

Veugelers, R., *A lifeline for Europe's young radical innovators,* Bruegel Policy Brief, 01, 2009.

# *ANNEX - List of K4G Members*

- **Chair:** Commissioner **Janez Potočnik**

- **Vice-Chair: Dominique Foray** (French), Professor of Economics at École Polytechnique Fédérale de Lausanne, Dean of the College of Management at EPFL (CH).

- **Bart van Ark** (Dutch), Professor of Economic Development, Technological Change and Growth at the University of Groningen (NL) (Vice-Chair of the Group 'Knowledge for Growth' 2005/2006). Executive Director of Economic Research at The Conference Board (US).

- **Maria Carvalho** (Portugese), European Commission, Bureau of European Policy Advisers. Former Portuguese Minister of Science and Higher Education.

- **Paul A. David** (American), Professor of Economics at Stanford University (US), Professeur Titulaire of Innovation & Regulation in the Digital Economy at Ecole Polytechnique and Telecom Paris Tech (FR) and Professorial Fellow of UNU-MERIT (NL).

- **Jean-Paul Fitoussi** (French), Professor of Economics at the Institut d'Études Politiques de Paris, President of the Scientific Council of the Institut d'Études Politiques de Paris (FR).

- **Anastasios Giannitsis** (Greek), Professor of Economics at the University of Athens (GR). Former Greek Minister of Foreign Affairs and Minister of Labour and Social Security.

- **Marianne Kager** (Austrian), Chief Economist of Bank Austria Creditanstalt (AT).

- **Bronwyn H. Hall** (American), Professor at the University of California at Berkeley (US) and Professor of Economics of Technology and Innovation at the University of Maastricht (NL).

- **Georg Licht** (German), Director of the 'Industrial Economics and International Management' department at the Centre for European Economic Research (ZEW), Mannheim (DE).

- **Jacques Mairesse** (French), Inspecteur Général at the 'Institut National de la Statistique et des Études Économiques' (INSEE) and senior researcher at CREST and at GRECSTA (FR).

- **Ramon Marimon** (Spanish), Director and Professor at the European University Institute in Florence (IT) and Professor at the Department of Economics and Business of Universitat Pompeu Fabra, Barcelona (ES). Former Spanish Secretary of State of Science and Technology.

- **Stan Metcalfe** (British), Professor of Political Economy and Executive Director of the ESRC Centre for Research on Innovation and Competition at the University of Manchester (UK).

- **Mojmir Mrak** (Slovenian), Professor of Economics at the University of Ljubljana (SI).

- **Mary O'Sullivan** (Irish), Professor of Economics at Wharton Business School (US).

- **André Sapir** (Belgian), Professor of International Economics and European Integration at the Université Libre de Bruxelles (BE).

- **Reinhilde Veugelers** (Belgian), Professor of Economics at the University of Leuven (BE), fellow of the think tank Bruegel, Brussels, and a former member of the Bureau of European Policy Advisers at the European Commission.

Comprehensive information on reports, policy briefs and conferences of the *Knowledge for Growth* expert group is available under http://ec.europa.eu/invest-in-research/monitoring/knowledge_en.htm

For further information contact the Group's Scientific Secretary Dr. Werner Wobbe:
werner.wobbe@ec.europa.eu

European Commission

**EUR 24047 - Knowledge for Growth**
**Prospects for science, technology and innovation**

Luxembourg: Publications Office of the European Union

2009 — 78 pp. — 21 x 29,7 cm

ISBN 978-92-79-13155-4
ISSN 1018-5593
doi: 10.2777/47564

## How to obtain EU publications

**Publications for sale:**

- via EU Bookshop (http://bookshop.europa.eu);
- from your bookseller by quoting the title, publisher and/or ISBN number;
- by contacting one of our sales agents directly. You can obtain their contact details on the Internet
(http://bookshop.europa.eu) or by sending a fax
- to +352 2929-42758.

**Free publications:**

- via EU Bookshop (http://bookshop.europa.eu);
- at the European Commission's representations or delegations. You can obtain their contact details
on the Internet (http://ec.europa.eu) or by sending a fax
- to +352 2929-42758.

In the context to reinvigorate the Lisbon Strategy, European Science and Research Commissioner Janez Potočnik established a group of prominent economists to explore the contribution of knowledge to sustainable economic growth and prosperity. This group was called the "knowledge economists" or the "K4G Group". The experts and group members discussed reports on the relationships between science, technology, innovation and the economy and the optimum mix of policies needed to promote the creation, dissemination and use of knowledge and the role that the various actors can play in stimulating a knowledge society.

The publication has selected outstanding policy relevant contributions from the K4G Group that bear prospective potential for European science, research and innovation policies. The contributions deal with issues to go beyond the R&D deficit, with issues of diffusion and specialisation strategies, with university's research organisation as well as with knowledge organisation and diffusion to combat the economic crisis. The kind of specialisation science and research should take in European regions forms the overriding "leitmotif" of discussion in the "Knowledge for Growth Expert Group".

The report can be downloaded at:
http://ec.europa.eu/research/era/publication_en.cfm

KI-NA-24047-EN-C

Publications Office

ISBN 978-92-79-13155-4