PRIME NETWORK OF EXCELLENCE
Policies for Research and Innovation
in the Move towards the European Research Area

Knowledge dynamics and ERA integration

An exploratory project within the PRIME Network of Excellence

Coordinator: S. Kuhlmann, University of Twente
Partners: Peter van den Besselaar, Dietmar Braun, Jakob Edler, Gaston Heimeriks, Luisa Henriques, Philippe Larédo, Terttu Luukkonen, Barend van der Meulen, Maria Nedeva, Daniel Pardo, Emmanuela Reale, Antoine Schoen.

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By P. Larédo and S. Kuhlmann

The issue at stake: One size does not fit all

European integration has predominantly been discussed focussing on an institutional dichotomy of national vs. European levels of action – also in the field of science and innovation policy. To a significant extent, the arguments are financial and based on critical mass considerations: 'subsidiarity' suggests that there is interest in pooling resources only in situations where efforts are too important for just one country. However, more and more, organisational arguments have prevailed. During the 1990s the so-called European paradox was a prevalent construct which supposed that Europe was good at science but poor at exploiting it. Since 2000, with the ERA initiative, what previously was considered as a source of richness (diversity) turned into a source of weakness (fragmentation). Such analyses might hold at the macro level (Europe takes less patents, Universities rank weak in terms of academic output …), however they do not enter in the "black box" of actual knowledge production and utilisation. As a consequence, they do not help policymakers much with the design of appropriate public interventions and the decision about what is the best level for policy intervention. Since such analyses are normally built on selective examples in order to fulfil specific purposes, they should not be generalised – but this is what happens all too often.

Accordingly, one can always find cases of success or failure that can illustrate the point made and the policy proposed.

At the same time “Europeanisation” – and indeed internationalization – goes on in science and innovation. Are we witnessing the rise of a European science system, an integrated, fully-fledged landscape of science and research institutions and related public organisations? Does such a system develop at the cost of the inherited national public bodies and their independence (university system, academies, research councils, ministries, agencies …)? Would this be desirable? There are indeed strong signals that the national dimension is losing its predominance and is no longer the only horizon of public research (funding) organisations and their strategic actions. For example, almost 100 ERA-Net projects have come about, creating new kinds of joint trans-national activities of national research funding agencies and policymakers, including joint calls and programmes: “ERA-NET fulfilled a real need within the policy armoury of the EU in that it helped overcome barriers to the coordination of national and regional re-search activities, a vital step in the creation of a real European Research Area.“[1]

It is doubtful that we can understand the organisational and institutional changes towards a “post-national” settings of research organisations and institutions – and the role of ERA therein – adequately applying just ‘subsidiarity’ or ‘critical mass’ arguments. We might miss the point if we do not take into consideration the quite specific dynamics of thematically different fields of knowledge production. The actual evolution of both national and transnational institutional arrangements depends upon the content and the dynamics of research activities, on subsequent innovative patterns and all the related interactions within different thematic fields or sectors. At the same time this evolution is influenced by national institutional settings and also by given European traditions in research and innovation collaboration. In consequence, we are witnessing different “configurations” that entail different forms and directions of institutionalisation and levels of “integration” or even disintegration in Europe for different technologies (or knowledge areas).

We suggest that, *at any time*, we face different configurations of knowledge production and with them the need for specific mixes of policy interventions at the three policy levels. Dealing with ERA this means that, even within a fully fledged ERA we should witness different relevant spaces for public intervention, as we de facto accept that some fields (like aerospace or IT) require European level research policies while others (like fashion) are the realm of “creative cities”, clusters or industrial districts.

The issue is then to identify and characterise such different “ERA configurations”. We are not aiming at explaining in detail all kinds of knowledge dynamics, but to identify and characterise different *basic types of configurations in regard with policy-making requirements.* There are two major dimensions of policy requirements, dealing with (1) the instruments and incentives relevant for performative public intervention, and with (2) the

[1] See Horvat, M.; Guy, K. et al. (2006): ERA-NET Review 2006 (Brussels).

adequate “level of integration” required (that is who should be the leading public authorities catalysing public intervention in knowledge creation and circulation). This means that configurations may vary in terms of actor constellations or local dynamics while “requiring” similar knowledge infrastructures and incentives.

The proposed conceptual framework

We use the recent work done by Bonaccorsi on ***search regimes***[2] making the point that we should not consider the whole of ‘science’ as such and thus expect one general type of knowledge dynamics (reaching from science to innovation) and one unique set of appropriate supportive public policies. On the contrary we argue that dynamics are differentiated depending on fields and sectors.

For science-led areas, Bonaccorsi proposed three abstract properties explaining these differences.

- The *rate of growth* differs widely between fields. Take as a simple marker publication in the ‘World of Science’: while the average yearly growth is around 1%, genomics has been growing for the last 10 years at 8%, and the recent rate of growth of nanoscience has been near to 14% (catalysis has a similar rate of growth as we shall see when looking at Chemistry)! One can imagine the effects of such differences by simply taking an image from management: it is well known that established positions in a market can change very rapidly when the rate of growth is 5% and higher. What happens with institutions and countries that cannot follow such a rate: marginalisation and uproar by scientists like in France in 2004 with life scientists!
- In fields that are established (with a dominant design or in ‘normal science’ under a given paradigm), knowledge tends to be cumulative, meaning that two different pieces produced in different places will converge toward deepening the given paradigm. But when a new paradigm is emerging, actors enter in a wide exploration, multiplying directions, and this divergence, as shown by recent biotechnology, can remain for a long period, driving to very different conditions under which new knowledge is circulated and generalised. The relative degree of *convergence or divergence* is thus a second key abstract property central for considering the differences in productive patterns.
- We are familiar with the growing need for facilities and equipments (remember the term Big Science), we all know the importance of inter-, multi-, or pluri-disciplinarity in the emergence of frontier science, we have been advocating the need for inter-institutional linkages for relevant problem-solving knowledge to be produced (collaborations between university and industry or between researchers and clinicians …). All these represent cognitive, technical and institutional *complementarities*.

[2] For those interested about this new theory on knwoledge production, see the full presentation made at 2005 PRIME conference (www.prime-noe.org).

> Obviously, these are quite different for a high energy physicist, a mathematician, a chemist, a biotechnologist or a nanotechnologist.

This third characteristics takes into account the ways in which users and in particular industry, through institutional complementarities, co-produce knowledge. However, complementary aspects need to be taken into account, as demonstrated by the work on technology systems or on sectoral systems of innovation, to fully grasp the differences between sectors in the interaction between innovation activities from industry on the one hand and the production of knowledge on the other hand. The – international – structure of sectors which draw on specific scientific knowledge, the specific needs for new knowledge and the established or emerging interaction between industry and science for the generation and transfer of knowledge thus also impinge upon the needs and provisions for international coordination.

Our assumption is that not only are the regimes and overall configurations different between fields, but they also differ between successive "leading sciences" (see exhibit below). The properties of high energy physics are very different from those from the IT wave which themselves cannot be assimilated to those of the bio wave focused on individual IP and start-up mechanisms. The work done within PRIME on nanotechnology[3] argues that the picture differs once more with a key role of incumbent firms and a level of industry-university cooperation rarely witnessed up to now.

'Dominant science'	Physics	Computer science / TI	Molecular biology	Nano 'convergence'
Dynamics / crystallisation (Cognitive complementarities)	Large objects or technical systems	Distributed PI (patent pools…)	Science bases / individual PI & transfer/licences	Hybridisation of 'long distance' disciplines
Trajectory (degree of convergence)	Early selection of a dominant design / cumulative improvements	Adoption of standards and design	Competition between paradigms	(initially) based on previous trajectory of central 'discipline' / alternative "bottom-up" explorations bringing divergence
Critical infrastructures (technical complementarities)	Specific very large equipments	Generic infrastructures (broadband networks…)	No entry barrier	Technological platforms – interdisciplinary gatherings
Coordination mode (driving institutional complementarities)	National large programmes (product oriented)	Technological programmes Strong industry-university	Networks & clusters (bottom-up)	Multi-actors poles (PPP): 'nanodistricts'

[3] See the nanodistrict project, www.nanodistrict.org or www.prime.org ; see also the special edition of Research Policy coordinated by Bozeman, Larédo and Mangematin (under press).

		relations		
Main industrial actors	National champions (specialising in "public" infrastructures/ services)	MNF (oriented toward mass markets) / specialised NTBF (B to B)	Start-up & venture capital (in early phases) (concentration around large established firms in wider diffusion)	Central role of incumbents (global firms BtoB and Bto C, ex start-up from previous waves)
'representative' industries	Nuclear energy, space, civil aeronautics, fixed numerical telecoms	Information technology, mobile communications	biotechnology	??

Source: Laredo, 2006, Lettre de la Régulation N°56

The very crude characterisation of successive S&T waves proposed above helps uncovering our hypotheses on the present time and the questions they raise for policy making as illustrated by the very different policies exhibited.

This means that optimal coordination and integration (national, regional, European, global), both in terms of organisational forms of knowledge production and transfer, and of public intervention, would strongly vary depending upon the type of "configuration" faced. This would also help to address the endless debate about critical mass and the optimal size of labs, providing a clear answer: it depends upon the specific knowledge dynamics. One can afford small groups of high-level mathematicians but doubt that such a setting will be effective in biotechnology with the rise of platforms or in nanoscience with the need for clean room facilities on top of a renewed set of equipments.

In order to give a better view of the potential diversity of configurations and of their policy implications, here are some conjectures on the dynamics of selected knowledge fields / industries (aiming to capture both dimensions, thus partly departing from Bonaccorsi's concept of scientific search regimes).

- In sectors like aeronautics, the dynamics is driven by the development of new complex products (the vision and long-term programme of the technology platform is a clear example of this). The key actors are large world oligopolistic integrators (arrived at after a long period of mergers and acquisitions which has largely disconnected firms from their "country of origin"). We face a trend toward specialisation of both knowledge producers and firms. In such a situation, public intervention, apart from the usual role in education (with the associated research), is focused, as demonstrated by history (with AIRBUS or ESA), on a "federal level" approach of the new complex products that correspond to policy priorities or requirements (e.g. for CO^2 emissions). Adopting such a framework might help understand past successes (like for wind energy, following the EC megawatt windmill research and demonstration programme).

- For the biotech industry, on the contrary, recent studies tend to show that the dynamics is based on 'individual' breakthrough knowledge and market emergence pushed by start-up firms. What matters, on top of an adapted framework for intellectual property and seed/venture capital, is the size and variety of the science base. A comparison with the US would demonstrate that Europe was paradoxically missing more variety than size, the fragmentation of research funding agencies driving to focusing more funds on the mainstream agenda and far less on heterodox alleys, sources of new paradigms and future Nobel prizes. In policy terms, this would require more 'federalisation' not of targeted programmes but of the funding of fundamental and academic research.
- In cases where like IT where we find, at the same time, a variety of options, the need for sharing knowledge (translated in the central role of patent pools) and high entry costs for production facilities, standardisation (in this case through the microelectronics roadmap) turns central to structure the progressive integration of new knowledge produced. In such situations, targeted programmes for technology generation based on industry-industry and industry-university cooperations have proven performative on the long term. At the same time, in microelectronics (and now nanoelectronics) research, strong concentrations in a limited number of geographical poles appear to be successful (as in Grenoble, Leuven and Dresden).
- Knowledge production in many other fields and industries is based on lower level aggregations. And domains like chemistry witnessing slow growth, a standard lab production model in public research and long-established bilateral university-industry relations do not require to move from the national to the European level of integration, at least in "mid-size" countries like France, Germany or the UK. Fields like Chemistry are interesting for two reasons: (a) depending of the member state, there might be different "needs" for integration and different views, reflecting the different national "critical masses". (b) Fields do not grow only because of "intrinsic" dynamics; they also grow because of "extrinsic" pushes: such has been and is the case of catalysis because of the energy crisis, then the environment issues and now because of research at the nanoscale in numerous other fields. Such might be the case with the adoption of the REACH agreement which will change the basis under which the industry operates, and possibly completely renew the approaches to knowledge production.
- Sectors like textile, plastics, furniture or fashion and many more have been heavily investigated because of the importance of local agglomerations in the performance of SME. They have driven to numerous works on industrial districts, innovative milieus, clusters, poles, creative cities, and not least on regional systems of innovation. Related studies argue that, on top of the regulatory framework, what makes the difference in the competitiveness of firms is linked to their "local" environment, including higher education and public research. It is more and more accepted that proximity does not only apply to producers but also to public authorities and that the best fit to support such situations stand at a lower level than the national one (at least in "mid size" countries such as Spain or France), thus the strong decentralisation, devolution moves observed (even if the first things regional authorities have often done is to focus on fast growing fashionable, high tech sectors).

These examples do not represent a "taxonomy" but should simply illustrate how different knowledge and innovation dynamics may entail very different foci for policy intervention, and with them very different public authorities (giving a conceptual substrate to multilevel governance), or more exactly driving to a synergy in interventions based on complementary targets.

The PRIME ERA-Dynamics exploration underway

The project presented at the workshop has four objectives:

a) Further elaborate the *conceptual framework*. A first version articulating knowledge and institutional dynamics will be proposed at the Bonn meeting.
b) Start a *discussion with policymakers* and policy analysts about the potential for such an approach to feed into foresight programmes and strategy making processes, and the developments needed to turn it "practical" in order to make multi-level policy-making more responsive to the specific needs of knowledge areas.
c) Develop a *first experiment* within one field, next to the work being done (indirectly) in the PRIME project dealing with nanoS&T. The case of *Chemistry* has been chosen because of the reasons exposed above. The objective is dual. We wish first to see how we can operationalise both a "domain delineation" and develop indicators on the three dimensions of search regimes. And we aim at analysing public institutional dynamics of operators, agencies and institutions supporting chemistry in Europe, and the experiments and attempts made of sharing at the European level (with a focus on present times with technology platforms, ERA nets and NoEs). Preliminary results will also be discussed in the Bonn meeting.
d) Elaborate a first analysis of the role of "new" EU level instruments and structures (networks of excellence, technology platforms, ERA Nets, the Open method of Coordination and the European Research Council), considering that they represent a source of variety in the portfolio of policies and instruments available for actors to adapt to and promote changes in knowledge and innovation dynamics. Our assumption is that we are in an experimentation period and that is is important to see how differently actors mobilise and shape tools (avoiding any normative stand about how they "should work"). Our first step has been to focus on ERA-Nets which represent for most policy analysts a truly unexpected development.

The Bonn meeting will offer the occasion to present for the first time our approach both conceptually and in a practical level with the test on Chemistry. The discussion will help us, no doubt, to enter in a second round of conceptual and experimental work.

This should enable us to hold a second workshop in Lisbon (November 15th) focusing on a first elaboration of configurations, on a second round of indicators of characterisation, and on a better understanding of the roles of new EU level instruments.