Recommendation for the Map of EU Excellence and Specialisation in Research, Innovation, and Science for Evidence-Based Policy Making

Policy Paper by the Research, Innovation, and Science Policy Experts (RISE)

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THE NEED FOR A MAP OF EU EXCELLENCE AND SPECIALISATION

Art. 179(1) of the TFEU states that "The Union shall have the objective of strengthening its scientific and technological bases […]." Furthermore, excellence finds itself at the heart both of the mission letter sent by President-elect Juncker to Commissioner-designate Moedas on 10 September 2014[1] and the program outlined by Commissioner-designate Moedas during his hearing in front of the European Parliament on 30 September 2014, who declared: "My third priority will be to defend the value of excellence in science and research."[2]

The EU falls short of the critical masses of funding and talent needed to achieve global scientific and technological excellence (Bonaccorsi et al., i4g, 2013). Moreover, the gap in economic competitiveness between Europe and the rest of the world, in particular North America and emerging countries like China is increasing (Llerena, i4g, 2013). The analyses in the i4g Policy briefs mentioned above are consistent with the academic literature. For example, Albarrán and co-authors (Albarrán et al., 2010; 2011a; b; c; d) have offered a full scale analysis of indicators covering the entire distribution of citations of scientific publications, using several alternative definitions. They reach the conclusion that Europe lags behind in citation distributions according to all available measures. These findings support the findings in the earlier literature about the position of European science (Dosi, Llerena and Sylos Labini, 2006; Aghion et al, 2010; Bonaccorsi, 2007; 2011).

It is important to note that these findings do not depend on the issue of position of European universities in global rankings. As a large literature has shown, there are several methodological shortcomings in rankings (see among others the discussion of the specialized literature in Salmi, (2009) Kehm and Stensaker (2009), Dehon et al. (2009), Shin et al. (2011) and Hazelkorn (2001), as well as the institutional considerations in Rauhvargers (2011) and the methodological analysis of Saisana et al. (2011)). To say the least, rankings do not constitute a robust empirical base for policy-making.

A related issue is one of specialisation. Europe has a broad base of scientific excellence and of manufacturing and service production. However, not always the areas of specialisation are those which grow more at world level. Also, only in a few cases Europe benefits from the advantage coming from a strong specialisation in areas in science *and* industry that are related and support intense flows of knowledge (as it happens in life-sciences and IT in the United States). Finally, at territorial scale there is a recognition that there are several pockets of excellence, i.e. small scale agglomerations of high level competences, often originated in the public research sector, which however lack the critical mass and the linkages with industry to originate spillovers. Thus specialisation is the other side of the coin of the problem of excellence.

These findings raise two immediate, crucial, operational questions for EU research, science, and innovation policy makers, namely,

- "How can the Union constitute a critical mass for global excellence?" and
- "How should public authorities leverage funding to maximize EU excellence?"

The answer to these questions cannot rely on assumptions. It must rest on evidence, evidence not only on scientific and technological excellence itself and on related patterns of specialisation, but also evidence on the national, regional or local impacts of public expenditure on, e.g., employment, growth, and productivity.

However, while some tools like U-Multirank[3] or Mapping Scientific Excellence[4] have become available and deserve attention, they have a different aim and therefore remain limited in terms of

- scope and ability to establish a comprehensive list of Public Research Organisations (PROs);
- disambiguating the innumerable ways in which PROs show up in bibliometric information and normalizing affiliations;
- locating the scientific production of PROs geographically at a fine resolution (Nomenclature of Units for Territorial Statistics level NUTS 2 and possibly NUTS3);

1 http://ec.europa.eu/about/juncker-commission/docs/moedas_en.pdf
2 http://ec.europa.eu/avservices/video/player.cfm?sitelang=en&ref=I093025 (2'46")
3 www.u-multirank.eu
4http://www.excellencemapping.net/#/view/edition/2014/measure/top10/calculation/a_ohne_kovariable/field/materials-science/significant/false

- integrating data on publications and other relevant indicators from HEIs and PROs at territorial level
- analytical and display capabilities.

It must be said that the experience gained by the European Commission in producing indicators on research, innovation and competitiveness is state of the art at world level. Recent commissioned studies [5] do a great job in offering new batteries of S&T indicators. Existing systems of indicators and studies, however, do not allow for aggregation and disaggregation of data according to specific policy-relevant questions.

Filling this void requires a radical departure from the traditional way of conceptualizing and modelling the problem. In other words, rather than the launch of ad hoc studies to address these issues, what is needed is a permanent IT platform, to be characterized by interoperability, scalability and flexibility in the range of indicators that it can sustain. This departure is now made possible by the fast developments taking place in computer science, particularly with the advent of Ontology Based Data Management (OBDM). Such a platform should allow, among other applications, the production of a geographical information system (GIS) that combines and georeferences robust empirical data from various sources at different geographic scales (NUTS 2 and possibly NUTS 3) to map excellence and specialisation, documents impact of public expenditure when data are available, and provides indicators for policy use.

Basically, the idea of a Map of Excellence and Specialisation means the creation of a platform which includes all higher education institutions and Public Research Organizations (beyond a given volume threshold), defined according to officially validated Authority Files, associated with data on inputs (basically, various indicators of staff and funding) and outputs (initially, various batteries of indicators from scientific publications with a fine disaggregation by discipline). The data on HEIs and PROs should be appropriately geo-referentiated (which requires some initial research effort) at NUTS 2 and possibly NUTS 3 level. The platform should be fully compliant with all existing definitional standards in the field of S&T and be inter-operable and scalable, from an IT point of view. Once created, the platform will allow the integration of a large set of socio-economic indicators at various geographic scales, as well as the integration with other indicators of inputs (e.g. European funding) and outputs (e.g. patents, international collaborations, industry-university co-authorship etc.). In future releases not discussed here, the Map might also include end georeferentiate data on research and innovation from actors not included in the perimeter of the public sector (i.e. companies and NGOs).

The platform should allow the production of various families of indicators, allowing the analysis of volume, quality and impact, critical mass, specialization, and complementarity. The definition of excellence should be made variable, according to indicators available and differences across disciplines and territories. Data should be aggregated and disaggregated following different lines, allowing flexibility in the production of policy-driven indicators.

See Annex for a first list of indicators to be included in the EU ‘Map of Excellence and Specialisation’.

5 One remarkable example is Cambpell et al. (2013).

WHERE IS THE ADVANCEMENT WITH RESPECT TO EXISTING SYSTEMS OF INDICATORS?

The idea of a Map of Excellence and Specialisation tries to address some gaps in the production of indicators for policy making and at the same time capitalizes on the opportunities created by very recent developments in the availability of data and in computational techniques.

We need to go beyond the current state along several dimensions, namely *granularity*, *cross-referencing* and *interactivity*. We suggest these dimensions will be of increasing interest to policy makers in the near future.

By *granularity* we mean the possibility of examining research production at various scales of aggregation, without being limited by ex ante decisions of the compilers of studies. There are at least three dimensions of granularity that are not served well by existing studies and that will be of increasing interest for policy making:

- geographic, or territorial
- institutional
- disciplinary

By *geographic* or territorial granularity we mean the possibility to zoom from the highest levels of aggregation (world level, EU level) down to country level, but also to regional (NUTS 2) and, whenever possible, province or city level (NUTS 3). Existing studies allow to examine the performance and specialization of countries and of a limited set of regions, but do not permit to aggregate or disaggregate data upon demand. Furthermore, no exploration has been done on the *urban* level (e.g. large cities), which is known from a large literature to be the most important one to research activity.

Second, in the European context there is also a large *institutional* diversity in the scientific system, in particular in the distinction between higher education institutions (HEIs) and public research organizations (PROs). This distinction is not visible at all in existing statistics.

Finally, *disciplinary* granularity implies the possibility to use several definitions of scientific disciplines, again changing the level of aggregation depending on the policy question at hand. For example, in some cases what is needed is a broad characterization of scientific activity (say, Health sciences), but in many relevant cases the kind of information needed by policy makers is defined at a much more disaggregated or granular level (say, Toxicology). This is not made possible by existing studies. Consider that the number of subject categories in scientific journals is in the order of 250 in STEM disciplines, while current studies publish aggregate data on 15-20 broad areas.

The second unsatisfied need is *cross-referencing*. This implies the possibility to combine several sources of data in order to obtain new indicators, without the burden of building up new databases from the scratch. Let us take two examples on issues that are at the core of most studies on innovation, which often formulate clear policy recommendations: the complementarity between scientific research and patenting, and between education and research.

If one wants to go beyond case studies and empirical studies on small samples and tries to examine the relationship between scientific publications and patenting of Europen universities, she must start an original study, reconciling and integrating existing but heterogeneous databases. No current tool allows to integrate publication and patent data at the level of individual institution. To make another example, if one wants to study the relationship between human capital formation and research in order to foster innovation, she must rely on highly aggregated data, because data at local level (NUTS 3) or regional level (NUTS 2), and even more at institutional level (microdata) are not integrated.

Cross-referencing requires a great deal of work in definitional issues and testing of comparability. The statistical properties of indicators obtained from different sources must also be tested carefully and validated from a scientific point of view. But once established, cross-referencing delivers large gains in the production of new indicators.

Finally, we believe the whole field of S&T indicators must be aware of the new trends towards *interactivity*. The traditional approach is one of producing indicators at fixed dates. The kind of indicators available are defined ex ante. The users can neither modify the indicators, nor demand new ones until the next release, often with large additional expenses.

Existing technologies allow much more flexibility. [6] It is true that indicators must satisfy a number of statistical properties in order to preserve reliability and validity, so that the do-it-yourself is not realistic. There must be a careful study of the potential for creation of new indicators. However we suggest that also for policy makers there will come a time where the demand for indicators will imply much more interactivity that is the case with current solutions.

WHO ARE THE USERS OF THE MAP OF EXCELLENCE AND SPECIALISATION?

The are several users, each of which might have a different motivation to use the Map.

The first motivation is related to the crucial issue of the *relationship between research excellence, innovation and growth*. In the European context this old question is made more problematic because of the persistence of gaps with laggard regions and countries (cohesion policy). We have not the room here to address this important issue in substantive terms. [7] However, it has become clear from many studies in the last years that this question has not a unique and easy answer, one that holds across scientific fields, technologies, industrial and service sectors, countries and regions. To deliver to policy makers a realistic (not messianic) message, which is based on the best available evidence, we must avoid simplification and offer articulated answers. What is needed is an extensive work of empirical analysis with the finest possible level of disaggregation of data.

For example, measures of human capital are often constructed, due to the limitations of data, by computing the share of population with a tertiary degree. But we know that the impact of human capital on innovation depends very much on the field of education (for example, the creation of startup companies is facilitated by education in engineering and medicine), on the degree of education (e.g. undergraduate vs. postgraduate students), on the density of skills (e.g. urban environment vs others), on the complementarity between human capital employed in companies and in the public research sector. In all these cases there is a need for disaggregated data and time series.

The second broad motivation is *to create tools for policy making within the move towards the European Research Area*. The overall ERA concept relies on the notion that the integration of research systems at European level will bring benefits in terms of scale, competition for quality, cooperation and specialization. Yet we do not have the tools to examine changes in performance and specialization across European countries and regions.

Finally, the overall policy orientation towards *Smart Specialization* will require an extensive use of data at regional and sub-regional level, which are not currently available. The overall notion of smart specialization rests on the assumption that it will be possible to identify opportunities for diversification (related variety), a process in which the research activity plays a crucial role. Yet at regional level there are few examples of concentration of research activities in broad areas (e.g. the Biotech districts), so that the specialization of the region is out of question. More frequently, what is found is that there are niches of specialization, or pockets of excellence, often in well defined fields of research, that yet might be decisive for diversification. It is important to stress that the lack of reliable information at disaggregated level hamper the very possibility of examining specialization. It becomes difficult for the European Commission to monitor the evolution of smart specialization against the often unrealistic claims of regional governments.

Finally, there is a political consideration. Can Europe afford to miss a unified database on research, having the ambition to build a Research Area? In the US the Star Metrics initiative has started to produce exciting results in the last few months. In Asia there are initiatives for mapping science, usually with a strong commitment from governments.

Thus among the users of the Map of Excellence and Specialisation we would consider:

- the European Commission at the highest level, together with national governments, to substantiate the claim that research is conducive to innovation and growth;

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6 A notable example is represented by U-Map, which allows users to customize their search for information and has triggered large interest. While this is not targeted to policy makers but to the much larger audience of students and families, it is still a good example of the potential of interactive technologies.

7 This issue has been discussed repeatedly within by the Innovation 4 Growth groups and is currently on top of the agenda of RISE, as well is at the core of the research activity of several members of RISE. See for example Veugelers and Cincera (2010) and Sachwald (2013) on the relation between scientific excellence and creation of startup companies; Tsipouri (2013) and Rodriguez-Pose (2014) for the issue of the relation between R&D and growth in cohesion regions; and Mairesse, Mohnen and Kemp (2005), Cassiman, Veugelers and Zuniga (2007) and Raymond et al. (2013) on the issue of the relation between R&D, innovation and productivity.

- the DG RTD and national Ministries of Research, to monitor the evolution towards the European Research Area;
- the DG Regio, national and regional governments, to discuss and monitor the national and regional smart specialization strategies;
- the OECD, which is working on the integration between publication data and patents, as well as the construction of patent portfolios for large companies;
- academic communities and professional consultants involved in supporting public policies.

PREVIOUS ATTEMPTS AND FAILURES: WHY THIS TIME IT IS POSSIBLE TO SUCCEED

In order to evaluate the merit of the proposal, it is useful to examine why other initiatives that in the past have tried to achieve a mapping of research at European level have failed.

One of the main reasons behind the failures is related to the issue of updating. Information on S&T becomes easily obsolete, not only because the production of scientific knowledge is subject to a fast pace, but also because of the emergence of new fields, the entry of new journals, scientific conferences and societies, the change in disciplinary boundaries. Due to this dynamics, any information system that does not provide for regular, reliable and cheap updating is bound to be accepted with skepticism- and eventually fail.

Another reason is the cost of the operations. Finally, the take-up of the system by prospective users was not included in the design of the system, leading to a long delay in use- which, coupled with the issue of obsolescence of data, may be fatal.

There are several reasons why this time it is likely that the idea gets materialized.

First, the process of standardization of data on the S&T system is progressing rapidly, although with different speeds in different areas. This is a welcome development, one that would not have been anticipated a few years ago. Consider the following examples:

- ORCID (http://orcid.org/) is a non-profit organization, supported by research organizations, agencies, providers of publication management systems, and publishers, aiming at giving all researchers a unique identifier (ORCID_id number) and keeping it persistent over time. Established at the end of 2009, but operational since end 2012, it has almost reached one million researchers worldwide. Most of the increase has been achieved in a very short time frame: from 100,000 in March 2013 to almost 970,000 as of October 2014 (with 35% from EMEA countries);
- CERIF is a Europe-based initiative aiming at standardizing the operations of funding agencies, with the help of a full-scale ontology of almost all research products (http://www.eurocris.org);
- CASRAI (www.casrai.org) is a Canadia-US initiative for the standardization of data on research institutions and funders (also supported by one committee of Science Europe; http://www.scienceeurope.org/scientific-committees/Life-sciences/life-sciences-committee)
- ISNI (www.isni.org) provides lists and metadata on higher education, research, funding and many other types of organizations, while Ringgold (www.ringgold.com) does the same in the world of publishers and intermediaries.

These initiatives are strongly supported by international scientific associations (see for example CODATA http://www.codata.org and the VIVO network of scientists: http://www.vivoweb.org/).

The pace of progress of these initiatives has not always been satisfactory in the past. In particular, the CERIF standard was first proposed in 1991 and has a long history. However, it is likely that the standardization process will accelerate if the bottom up pressure from scientists themselves (in particular, with the ORCID initiative) will grow with the same pace as in the last couple of years.

In addition, the projects EUMIDA and ETER have provided an official list of higher education institutions in Europe, fully validated by National Statistical Authorities, associated to a number of descriptors and indicators.

Second, the technologies for disambiguating bibliographic data are currently more developed than in the past. Many exercises carried out in the past were hampered by the overwhelming cost of managing the traditional issues of disambiguation of names of authors (e.g. omonimy, abbreviation, truncation etc.). In practice, that required lot of manual work. [8] Even worse, it had to be repeated each time on ad hoc data. The situation improved substantially, however, in the last couple of years. On one hand, most scientific journals routinely adopt procedures to standardize the names and affiliations of authors. This is done in their own interest. [9] On the other hand, both producers of bibliometric data (Thomson Reuters and Elsevier) have embarked into initial efforts to disambiguate affiliations not only of universities (which was already done in the past) but also of the huge number of non-university organizations, gaining some experience. Even more importantly, techniques from computational linguistics and big data improved a lot in recent times, so that a substantial part of the work might be carried out automatically. The two trends (standardization of data and disambiguation techniques) clearly reinforce each other: for example, if there is ambiguity about a name, there are now available many tools to look for it automatically in the Internet, filtering the enormous noise in information through sophisticated semantic techniques, and end up with a small set of options- perhaps to be decided manually at the very end.

These developments are crucial for one of the most difficult tasks in creating a Map, that is, the geographic referentiation of research production and cross-referencing of data. This activity is in (relatively) mature stage for universities, but in the infant stage for other kinds of research organisations.

From a policy point of view, these developments do *not* solve the problem of mapping excellence and specialisation, but facilitate the solution. In other words, all bottom-up initiatives pushed by researchers and research institutions leave unanswered the question of representativeness of data (e.g. until a given country does not achieve a threshold of researchers covered, it may be sceptical about the data obtained). Thus we are not suggesting that bottom up initiatives substitute for official statistical and information systems. However, they enormously facilitate the work, since they offer exhaustive lists of institutions, standard definitions of all products of research, and ways to facilitate the disambiguation of information with automatic tools.

We need to have a vision of information systems on research that go beyond the current state of the art.

Thus we see the Map of Excellence and Specialisation as a necessary step between the current situation and a future one (perhaps in 5-10 years), in which most information on research might be managed autonomously by researchers themselves, with open data, achieving a level of reliability and validity acceptable for policy decision making.

RISE hereby recommends to the Commission to take the measures necessary to produce a 'Map of Excellence and Specialisation' for evidence-based policy making.

8 To take one example, within the Eumida project Ulrich Schmoch estimated that disambiguating data on universities would be easy for those cases in which just one institution is located in a city, but more complex for those cases in which several universities are present. He estimated informally that one month of work for each large city would be needed.

9 Disambiguation is crucial for IT-based manuscript management systems, which are becoming exceedingly complex in many scientific fields due to the number of submissions. I was told that in one case, due to a failure to disambiguate a name, a journal sent for peer review a manuscript to.. one of the authors! Luckily enough, the author replied by joking: "The paper is fine and deserves publication, but I might be in conflict of interest".

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ANNEX: INDICATORS TO BE INCLUDED IN THE EU 'MAP OF EXCELLENCE AND SPECIALISATION' GIS

Overall indicators of excellence in S&T

Excellence in S&T at NUTS 2 and possibly NUTS 3 level of European higher education institutions that deliver the PhD degree (i.e., universities) based on the results of the ETER (European Tertiary Education Register) study[10] and the last EUMIDA[11] data, when data are missing. The task will be based on those.

These data should be integrated with data on publications from a representative list of Public Research Organizations, selected with an aim of adequate coverage by country and by size of output. These data should be georeferenced and finally integrated with data from universities.

Once created, this platform would not only satisfy the issue of geographic referentiation, but also many other needs of analysis and support to evidence-based policy making.

Scientific publications

Scientific publications at the level of individual universities with a breakdown by disciplines using, e.g.:

- Number of publications
- Number of citations
- % of publications from top journals
- % of citations from top journals
- % of publications with international collaboration

The years covered should be the last available.

Specialization indicators

- Revealed Scientific Advantage of regions (NUTS 2), normalized both at EU and world level and possibly of provinces (NUTS 3);
- Position of NUTS 2 or possible NUTS 3 territory in European ranking by discipline, based on Number of publications both as an absolute and normalized against socioeconomic indicators, e.g. population;
- Position of NUTS 2 or possible NUTS 3 territory in European ranking by discipline, based on Number of citations (including derived indicators, such as share of publications among the 1% most cited).

Excellence indicators

Composite indicator including Number of publications, Number of citations, and Percentage of publications and citations from top journals.

Critical mass indicators

Flag (red/yellow/green) indicators stating whether the territory (country, or NUTS 2 or possibly NUTS 3) have or have not reached a given threshold of publications in given disciplines using the indicators developed by the EC as test cases.[12] Attention will have to be given to the determination of the threshold.

Several options should be explored: for example fixed threshold (e.g. number of publications per year per geographic units) vs. relative threshold (e.g. position in a ranking of European

10 Please see: http://www.european-net.org/2014/07/european-tertiary-education-register-eter/
11 Please see: http://datahub.io/dataset/eumida
12 http://ec.europa.eu/research/innovation-union/pdf/competitiveness_report_2013.pdf#view=fit&pagemode=none

agglomerations of scientific production). In the future the issue of global positioning should be addressed (e.g. position of European agglomerations in a worldwide ranking).

Research productivity indicators

- Number of publications per unit of academic staff
- Number of excellent publications per unit of academic staff
- Number of citations per unit of academic staff
- Number of excellent citations per unit of academic staff

Research intensity indicators

- Number of publications per 000 inhabitants
- Number of publications per million euro GDP
- Number of citations per 000 inhabitants
- Number of citations per million euro GDP

Research Excellence indicators

- Number of excellent publications per 000 inhabitants
- Number of excellent publications per million euro GDP
- Number of excellent citations per 000 inhabitants
- Number of excellent citations per million euro GDP

(End)

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The Policy Brief presents the concept and explains the need for the development of an EU Map of Excellence and Specialization. It draws a background analysis, explaining the interrelation between excellence and specialization and it explains current developments in the area of indicators, revealing the gaps that can be filled by the Map of excellence and specialization. Moreover, it considers the target audience of the Map, its potential user base, and the reasons why this endeavour is bound to be successful under the current circumstances.

Studies and reports

Publications Office

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