What do we need to measure to foster “Knowledge as Our Common Future”?

A Position Paper

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Abstract

This paper focuses on research and education and argues for a more balanced approach by the OECD to S&T statistics that includes various facets of science and knowledge in addition to the economic statistics currently being produced. This is because OECD S&T statistics have moved excessively towards capturing the “instrumental” value of S&T and innovation, STI. As a result, they now have a strong bias towards linkages with economic dimensions, and a rebalancing is required to fully capture the “intrinsic” value of S&T and innovation. There is a need to open up and enrich the production of indicators to capture a diversified set of skills, supported by theoretical advancements regarding the use of indicators and the navigation through data sets.

In addition, any next generation of data should better guide new forms of international cooperation giving priority to science, education and mobility. Data is also needed to foster the collective action of governments, public institutions and the private sector to promote the diversification of education and research systems leading to technological change, as well as a participatory approach to science and innovation.

In this regard, the paper identifies four main sets of data that require further refinements: i) research assessment practices and scientific career developments, which call for a major action of OECD to characterize those processes and guarantee the adoption of best practices worldwide; ii) migratory flows of highly skilled human resources, which call for a collective action of OECD at large, namely for the provision of data on forced displacement and including refugees, students and scholars who belong to communities and/or countries at risk in need of humanitarian assistance; iii) the recognition and characterization of practices and institutional intermediaries to help diversify research and education, including “professional practice based research” oriented towards professional development, as well as levels of institutional diversification and related risk-sharing mechanisms to foster skilled job creation; and iv) the need to better characterize participatory processes of R&D agenda setting to help engaging scientific structures with civil society.

Overall, the paper emphasizes the role that OECD statistics plays in advancing our knowledge and understanding of STI and building the foundations of an “evidence based STI policy analysis”.

1. Introduction

Twenty years after the first Blue Sky Forum in Paris and ten years after the second Forum in Ottawa (OCDE 20071), how far can we pursue one of the main preoccupations of NESTI2 and anticipate the demand for new indicators? In other words, which data do we need to better inform policy making about science and innovation? Above all, after a decade hit by recession

2 The OECD Working Party of National Experts on Science and Technology Indicators (NESTI) is a forum composed of a group of delegates from member countries, supported by the OECD/STI Secretariat.
and economic and budgetary problems, how far can we access the provision of science and innovation indicators?

This paper attempts to address these questions and focus on research and education. Although statisticians, analysts and policy-makers developed a sense of common interest over the last fifty years on S&T indicators, which prevented major controversies, time has changed and we live today in times of increasing internal divergence on knowledge investments across many world regions, including Europe, together with an emerging misuse of bibliometric data for research assessment and career developments in science and academia. This occurs at a time of an unprecedented flows of population that is suffering from forced displacement, with inflows of refugees from conflict-affected regions into neighboring countries and into Europe, together with the largest ever international-student population. In other words, investments in research and education have become a topic of conflict in global policymaking and require a better attention by the OECD and national statisticians.

To address this issue, this paper argues that OECD S&T statistics moved excessively (and tentatively) towards the economic dimension and require a better balance among the various facets of science and knowledge. This is not only to ensure that the “intrinsic” value of S&T and innovation is captured and valued, but also because during times of slowdown in economic activity – which has been the case since the global financial and economic crisis of 2008-2009 for many OECD countries – the economic value of S&T and innovation may be questioned by the population, in light of arguments of lack of effectiveness of “translating” S&T investments into growth in economic output. In addition, any next generation of data should better consider mobility and active participation of people, flow of knowledge and the increasingly transnational nature of business, technology and science.

The main driving rationale behind this paper is associated with the emergence of problems created by exacerbated inequalities for future growth. The quest for research and education data is, in fact, a quest for democracy at the global scale. A quest for sound regulation at a global scale, which inevitably implies regulating initiatives that can actually coerce governments to comply with their options (i.e. with options completely beyond democratic control).

The imperative of building knowledge-based societies demands an investment in our collective institutions to enable them to provide worldwide access to quality science education and scientific practices to everyone, regardless of age, origin or social and economic background. People at large will need to access knowledge and modern learning practices at all ages to build future generations who are becoming increasingly knowledgeable, creative and able to adapt responsibly to the challenges of a rapidly changing world. The futures of different people on earth are woven in a single garment. We all gain from the joy and benefits of discovery when all people participate in learning and the productive use of knowledge. This means reaching out and engaging our colleagues, scientists and lay people with young people in all parts of the world.

In other words, each generation should be able to explore new things and have the opportunities to do so. Although we all have understood that ensuring a sufficient supply of skilled individuals is important for promoting innovation, this need raises emerging questions about education policy as well as immigration policy in times of increasing uncertainty.

With this framework in mind, “Knowledge as Our Common Future” was launched in the summer 2015 as a public declaration (as available at www.knowledgecommon.com, and signed by hundreds of people) to promote an inclusive, open science culture through responsible Science and Technology (S&T) policy actions at a global level, by engaging scientists, policy makers and experts in continuous and long-term processes of constructive dialogue with society at large. It was established to foster the legacy of José Mariano Gago (1948-2015) and to engage government leaders, policy makers and experts worldwide to deepen the intellectual foundations of science and technology policy with the imperative of building knowledge-based societies in a world highly interconnected through information and communication technologies.

Also by that time, the OECD 2015 ministerial declaration on “Creating our Common Future through Science, Technology and Innovation”, (Daejon, Korea, October 2015) explicitly considers the need to continue improving statistics and measurement systems to better capture the key features of science, technology and innovation.

In addition, the adoption in the Autumn of 2015 of the 2030 Agenda for Sustainable Development and of the Sustainable Development Goals (SDGs) explicitly recognizes the role of science, technology, and innovation and includes the aspirations of leaving no one behind and protecting the planet. This is also recognized in the Addis Ababa Action Agenda, the outcome of the 3rd International Conference on Financing for Development, which underline the importance of technology, alongside finance, to enable the implementation of the SDGs.

Within this context, how far OECD statistics should promote the collective action of governments together with public and private stakeholders worldwide to effectively give priority to science, to education and to related public policies? In addition, shall this occur across all our societies and regions worldwide? In other words, do we have the conditions to engage in a new stage of global scientific collaboration and true knowledge diplomacy?

This position paper addresses these issues and present recommendations to the OECD and national statisticians within the spirit of a “blue sky initiative” in times of increasing uncertainty and on the rise of globalization. We start by briefly discussing in section 2 the current trend of OECD S&T statistics towards the economic dimension, which drives a set of recommendations to better balance the various facets of science and knowledge. Section 3 addresses the rational for this set of initial recommendations in terms of the need for characterizing global research networks. Then, in Section 4, the paper identifies four main sets of data that require further refinements, including: i) research assessment practices and scientific career developments; ii) migratory flows, which call for a collective action of OECD at large; iii) the characterization of practices and institutional intermediaries to help diversify research and education, including “practice based research” and levels of institutional diversification; and iv) the need to better characterize participatory processes of R&D agenda setting to help engaging scientific structures with the civil society. The final section presents a summary of our main conclusions and recommendations.

2. The OECD and the production of S&T indicators: an initial recommendation

It has become a consensus that S&T indicators are quite important both in social analysis and in policy making and that the role of the OECD in this field has been key and is likely to continue like that in the future9. A former director of OECD/DSTI, Robert Chabbal, once said: “Statistics are among the most visible and most extensively-used outputs of the OECD. If the OECD were to

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close its doors tomorrow, the drying up of its statistics would probably make a more rapid and bigger impact on the outside world than the abandonment of any of its other activities”.

But why we need the role of OECD to continue to be relevant in the area of S&T indicators?

To address this question, one should go back fifty years. In 1961 the OECD was formed and the Directorate for Scientific Affairs took over the work of the European Productivity Agency and convened a conference in 1962 to address technical problems measuring R&D. This happened under the directorship of Alexander King, a contemporary and colleague of John Bernal and with the support of people like Chris Freeman and Keith Pavitt. The main challenge at that time was to measure R&D and, in the end, its role in science on society at large. After fifty years the number of indicators has exploded and the pendulum has swung excessively towards the economic dimension, although “the link between the measurement of national STI activities and their national economic impact (while always subject to debate, particularly within the context of small countries), has now become so loose that national STI indicators are in danger of no longer providing relevant economic policy insights”.

Is this trend legitimate (as the OECD is an economic organization)?

Following Giorgio Sirilli, among many others, very little is really known about the direct impact of science, and yet it is universally recognized that the ultimate driver of productivity growth and improvements in well-being is tied to advances in science and technology. But while most studies and indicators are concerned with economic impact, which is important, this represents only a small fraction of the whole which extends to the social, organizational, and cultural spheres of society. As Cozzens argued: “The majority of [the measurement effort] has studied the process of innovation and not its outcomes. Traditional innovation studies still focus narrowly on making new things in new ways, rather than on whether the new things are necessary or desirable, let alone their consequences for jobs and wages”. Second, the few discussions and measurements that go beyond the economic dimension concentrate on indirect rather than ultimate impact.

Several factors contributed to focusing indicators on the economic dimension of science. Beyond the mission of the OECD, which is mainly an economic organization, economists have been the main producers and users of statistics and indicators on science and technology. Nelson argued that: “One would have thought that political science, not economics, would have been the home discipline of policy analysis. According to some, the reason it was not was that the normative structure of political science tended to be squishy, while economics possessed a sharply articulated structure for thinking about what policy ought to be” (Nelson, 1977). Also, Godin and Doré suggest that “it is the mystique of numbers that was at play here. Numbers have always seduced bureaucrats, and it was the economists, not the sociologists or political scientists, who were reputed to produce them, who were hired as consultants, and emulated.”

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10 OECD (1994), Statistics and Indicators for Innovation and Technology, DSTI/STP/TIP (94) 2.
14 Godin B., Doré C (2004), Measuring the Impact of Science: Beyond the Economic Dimension, CSIIC working paper, Ottawa; Also, paper presented at the Helsinki Institute for Science and Technology Studies.
In addition, the economic dimension of social phenomena is the easiest to measure. Most of the output and impact of science and technology is non-tangible, diffuse, and manifests itself with significant delay and often in unpredictable and even surprising ways\textsuperscript{15}.

Following Paul Nurse\textsuperscript{16}, “Research in all disciplines, including the natural and social sciences, medicine, mathematics, technologies, the arts and the humanities, produces knowledge that enhances our culture and civilisation and can be used for the public good. It is aimed at generating knowledge of the natural world and of ourselves, and also at developing that knowledge into useful applications, including driving innovation for sustainable productive economic growth and better public services, improving health, prosperity and the quality of life, and protecting the environment. This has always been the case since the beginning of modern science in the seventeenth century, when Francis Bacon argued that science improved learning and knowledge which “leads to the relief of man’s estate”, and Robert Hooke maintained that “discoveries concerning motion, light, gravity and the heavens helped to improve shipping, watches and engines for trade and carriage”. Today, for advanced nations such as the UK to prosper as knowledge economies, scientific research is essential – both to produce that knowledge and also the skills and people to use it. This is why science should occupy a central place in Government thinking, if the UK is to thrive in our increasingly sophisticated scientific and technological age. However, scientific research is not solely utilitarian, because it generates knowledge that more generally enhances humanity through culture and civilisation. In the words of Robert Wilson, Director of the Fermi Lab particle accelerator – when asked by the US Congressional Joint Committee on Atomic Energy whether the accelerator in any way involved the security of the country, he replied, “It only has to do with the respect with which we regard one another ... our love of culture..... it has nothing to do directly with defending our country, except to make it worth defending.”

Following these observations, among many others over the last decade, my recommendation to the OECD would be to redress an equilibrium in S&T statistics and pay more attention to the various facets of science and knowledge, relaxing the assumption that things are important as long as they deliver material goods. In particular, the role of research and education beyond driving innovation for sustainable productive economic growth, particularly in association with a culture of learning and knowledge, as well as driving better public services, improving health, prosperity and the quality of life, and protecting the environment, should be emphasized by OECD statistics. So, I would expect, as a result of the 3\textsuperscript{rd} OECD Blue Sky Forum, completely new indicators on unexplored but relevant areas of knowledge, in the true spirit of a “blue sky initiative”.

Going deeper into this recommendation from the “\textit{production-side}” of indicators, it should be noted that the development of S&T indicators in recent years has been basically in the hands of economists. It is time for other scholars, namely scientists, philosophers, demographers and sociologists, to let us understand how the knowledge creation enterprise works in terms of humans working together. In other words, what I would expect from the 3\textsuperscript{rd} OECD Blue Sky Forum is a debate on the need to open and enrich the production of indicators to a diversified set of skills.

On the other hand, from the “\textit{user-side}” of indicators, we are flooded with data. Open an OECD DSTI publication and you will see many, too many, indicators, not only S&T indicators \textit{stricto sensu}. Therefore, what I would also expect from the 3\textsuperscript{rd} OECD Blue Sky Forum is theoretical advancements in the theories that inform us how to safely navigate in the figures, beyond any

further refinements. This needs time and the OECD should take stock and guarantee accomplishments to be made in the coming decade.

In addition, there are other activities in relation to the existing set of OECD STI indicators that could deserve a comment. For example, the limited use, improvement, validity and exploitation (comparability) of GBAORD data from national S&T budgets, which requires further work to really make estimates of public investment, or regarding the role of competitive funding.

The rational for this set of initial recommendations to the OECD and national statisticians is further presented and discussed in the following section.

3. Deepening the rationale for action: The challenge of becoming global and the need for characterizing global research networks

The questions raised above are gaining increasing relevance as much of the political debate worldwide is centered on economic competitiveness in the long term\(^1\), most of the times under a rather “national” approach to science and innovation for growth. For example, a related question that does arises is if the acceleration of knowledge investments in Asia signal the decline of EU and should it be countered by aggressive “techno-nationalism” in the US and EU in any form?

Any new narrative on global research networks requires the analyses of, at least, the last decades and the seminal work of Sylvia Ostry and Dick Nelson (1995)\(^2\), among many others for the last twenty years, has called for our attention of the relationship between the globalization of firms and the nationalism of governments, as well as the related interplay of cooperation and competition that characterizes high technology and knowledge-based environments.

It should be noted that the Brookings Institution’s project\(^3\) of the early 90’s has promoted this debate, although in a different international context, and clearly showed that tensions about deeper integration arise from three broad sources: cross-border spillovers, diminished national autonomy, and challenges to political sovereignty. As a result, the technoglobalism of the 80’s gave rise to national policies designed to help high-tech industries become more innovative and, consequently, the emergence of technonationalism.

It is under this context that the concept of “national systems of innovation” has been developed and continuously assessed in academia, mainly through economists and related schools of thought, to explain and explore how and why the systems have evolved differently in the major industrial nations, mainly US, Japan, UK, Germany and France\(^4,5\). It was clear by then that the increasing international tensions and economic instability\(^6\) were largely a result of the attempt of governments to impose national research and innovation policies on a world in which business and technology are increasingly transnational.

_How should policymakers consider the increasing globalization of R&D spending?_ Ben Bernanke (2011)\(^7\) addressed this question a few years ago by remembering “the diffusion of scientific and

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19 Integrating National Economies, Brookings Institution.
22 See, for example, Galbraith, J. (2012), “Inequality and instability – a study of the world economy just before the great crisis”, Oxford University Press.
technological research throughout the world potentially benefits everyone by increasing the pace of innovation globally. For example, the development of the polio vaccine in the United States in the 1950s provided enormous benefits to people globally, not just Americans. Moreover, in a globalized economy, innovations in one country can lead to employment opportunities and improved goods and services around the world. On the other hand, the location of R&D activity does matter. For example, technological leadership may help a country reap the financial and employment benefits in a strategic industry. A cutting-edge scientific or technological center can create a variety of spillovers that promote innovation, quality, skills acquisition, and productivity in industries located nearby; such spillovers are the reason that high-tech firms often locate in clusters or near universities.

Following many OECD reports over the last decades, I argue for the need of a *global-local nexus* of institutions and processes, far beyond the scope of distant learning devices. This is even more needed since the pleading to go beyond techno-nationalism should not be misinterpreted as a plead for a global rationality in the sense of restraining the democratic will of governments that do not comply by the rules of capitalist globalization. As business has gone global, policies should go global too, in the sense that if policies really go global (i.e. in the sense that they will be reflecting democratic will) they will inevitably have to regulate the ways the private sector is acting globally.

It should also be noted that the claim for a new generation of S&T indicators aimed to stimulate enhanced global regulation may be detrimental for core countries who invest in innovation and lose large part of their potential gains through the workings of transnational corporations. The globalization of Apple’s production and value chain, as described by Maria Mazzucato, is a clear evidence of this fact. Also, for peripheral countries investing in human capital and then losing part of their investment through brain drain in other words, we need data to provide a reliable and complete picture why more regulation and control is needed at the global level for a more fair world.

The issues above bring necessarily the need to keep considering the key role human resources do play in science and innovation policies at large. For example, when viewed from the perspective of a single nation, immigration has been a critical path for increasing the supply of highly skilled scientists and researchers. Following again Bernanke (2011), the technological leadership of the United States (as well as the United Kingdom, and many other industrialized countries and regions) was and continues to be built in substantial part on the contributions of foreign-born scientists and engineers, both permanent immigrants and those staying in the country only for a time. And, contrary to the notion that highly trained and talented immigrants displace native-born workers in the labor market, scientists and other highly trained professionals who come to the United States tend to enhance the productivity and employment opportunities of those already here, reflecting gains from interaction and cooperation and from the development of critical masses of researchers in technical areas. More generally, lowering national barriers to international scientific cooperation and collaboration would enhance technological progress and innovation around the world, but it requires balancing brain circulation and migratory flows of skilled people.

This requires many measurements and observations and, certainly, deepening the debate in relation to the current economic and social situation worldwide. First, the myth of “national” high tech industries and related policies to protect them requires to be better understood, if

analyzed in terms of the increasing unemployment rates. Second, the debate itself on “national innovation policies” is in any case naive. No country, even in non-democratic regimes, ever seems to have had a broad, well coordinated innovation policy, mainly because of the complex structures associated with any “innovation ecosystem”. Following Gault (2010), any system includes linkages, feedback loops and non-linearity, with small changes in initial conditions resulting in major outcome changes. In addition, Mariana Mazzucato showed that it is essential to understand innovation as a collective process, involving an extensive division of labor that can include many different stakeholder. Again, economists have difficulty dealing with systems that are non-linear, complex, dynamic and global and, therefore there is a need to open and enrich the production of indicators to a diversified set of skills.

3.1. Strengthening the pillars: research and education

The discussion on the need for new science and innovation indicators should clearly be based on our intrinsic need to strengthen the basic pillars of education and science worldwide.

The need to effectively increase the level of R&D expenditure and, above all, public expenditure has become a recurrent issue worldwide, but increasingly relevant in the US and Europe, where overall expenditure on R&D is stagnant (or slightly decreasing) for many years. Consequently, the issue should be about the conditions to make that possible.

Recent legislative acts in many OECD countries considered substantial increases in R&D expenditure, the reality is different and the situation in many of those countries, including in southern and eastern European regions, is one of increasingly difficult conditions for research activities. Fiscal challenges, precipitated by concerns about the rapid growth in the deferral debt, leave the prospect of rising budgets for R&D uncertain. But which are the political, financial and social conditions that need to change in order to facilitate a better framework for R&D?

This question is relevant because after a decade hit by recession and economic and budgetary problems, there is the expectation that the links between research activity and its application in society will be reflected in more direct and immediate financial flows. However, this perception is leading to an institutional convergence between what higher education institutions do (and are supposed to do) and what firms and other agents do.

In fact, more than a decade after Burton Clark launched the idea of “entrepreneurial universities”, there is still much to learn about their impact and analysis has clearly considered this convergence a potential threat to the institutional integrity of the university and the future of scientific research due to the commoditization of knowledge.

The issue is not to “save the university”, but rather to understand who will play the fundamental and unique role that research universities have played in the overall cumulative system of knowledge generation and diffusion. It is clear that the US and EU elites are not willing to allow this integrity to be jeopardized. By misunderstanding national policies towards university-based research, there is a grave danger that university policy worldwide will destroy these basic functions, which would be detrimental to the global production of knowledge, but would also certainly harm the development prospects of many US and EU regions.

It should be noted that the US’s National Academies report on “How People Learn”32, published more than fifteen years ago, provides clear evidence that “designing effective learning environments includes considering the goals for learning and goals for students”. Given the many changes in student populations, tools of technology, and society’s requirements, different curricula have emerged along with needs for new pedagogical approaches that are more student-centered and more culturally sensitive. The requirements for teachers to meet such a diversity of challenges also illustrates why assessment needs to be a tool to help teachers determine whether they have achieved their objectives. But supportive learning environments, particularly fostering a culture of belief in science, need to focus on the characteristics of classroom environments that affect learning. In this respect, the authors were referring to the social and organizational structures in which students and teachers operate, including the environments created by teachers, but also out-of-the-school learning environments.

Following the practices, skills, attitudes and values described above, education at all levels should take into account that learning a new practice requires moving through discovery, invention, and production not once, but many times, in different contexts and different combinations 33.

To achieve these objectives, we must learn from new research and, certainly, we also need to foster evidence-based project and experimental work, as well as to focus our attention on the transferable skills students should acquire. But we also need to reduce dropout rates in tertiary education and to involve students in research activities from the early stages. In summary, we need to go beyond the structure of tertiary education and gradually concentrate our efforts on measuring and taking stock of the diversity and evolution of specific student-centered parameters.

3.2 Openness: research and education beyond national borders

Following the analysis of Freemann and Soete (2007)34, “from the perspective of the location of R&D, the twenty-first century STI indicators debate raises crucial questions about the relevance of domestic R&D policy strategies. These policies will have to put more emphasis on the public–private matching of international R&D specialization patterns with proven international excellence in research than on the competitiveness of national R&D policies between countries and regions”.

Looking at the present and tentatively forecasting the future, we argue that a new paradigm of international academic, scientific and technological cooperation that seems to be emerging as a major shaping factor for development at an unprecedented level.

Leading American research universities are playing a key role in this process worldwide, as a result of the accumulation of large investments in research and education over many decades until now. It should be clear that this is not a new issue. For example, Morgan (1979)35 describes the role US universities played in helping to build an indigenous S&T base in developing countries until the 70’s and how far American Universities have engaged into that process. Some thirty years ago, Morgan recommended universities and policy makers about the future

involvement on four areas: institutional building, cooperative R&D, resource base development, and education and training.

More recently this theme has been subject of various books and papers in the technical literature and, for example, the analysis of Bruce Johnstone\textsuperscript{36}, Altbach et al\textsuperscript{37}, as well as that of Knight \textsuperscript{38}, shows an active participation of US and EU universities in indigenous and local development practices, indicating related major advantages, as well as major challenges for them and national innovation policies in the near future. A recent report by the Royal Society of London further emphasizes these aspects in terms of scientific collaboration\textsuperscript{39}.

Emerging models of research and academic cooperation, that includes but do not seem to be hostage of the traditional forms of services’ international commerce, may derive their uniqueness from the very nature of academic communities and from the strong meritocratic and universalistic ideals that prevail in science on an international scale. In addition, they are also driven by the flow of students and researchers, and by the citizens sense of being part of a “mission” for scientific and social development that motivates some of the best professionals in academic and research institutions worldwide.

It is under this context that innovation policies should help fostering a better understanding of future international collaborative paths in education, science and innovation. Ultimately, this will become a key issue for competitiveness everywhere.

Recent analyses of university-industry-government relations show that structured international relationships may act as agents of change if associated with activities that are fundamentally different from the traditional role of universities, involving, most of the times, capacity building and various forms of social and economic appropriation of knowledge\textsuperscript{40}. They also require understanding the nature of international cooperation beyond the exporting/importing of “academic services” in all the institutions involved. In addition, they clearly break traditional boundaries of “national systems of innovation” and bring new challenges in terms of the necessary institutional integrity research and higher education institutions need to preserve and foster.

Again, we need to take stock of the diversity and evolution of university-industry-government relations and the way they are used to effectively increase the level of R&D expenditure and foster innovation.

4. Further refinements in the production and usage of S&T indicators: extended recommendations

Based on the rationale presented above, the following paragraphs identify four main sets of data that require further refinements, including: i) research assessment practices and scientific career developments; ii) migratory flows of highly skilled human resources, which call for a collective action of OECD at large, including for the provision of data on refugees, students and scholars who belong to communities and/or countries at risk in need of humanitarian assistance; iii) the characterization of practices and institutional intermediaries to help diversify research and education, including “practice-based research” oriented towards professional

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\textsuperscript{40} M. Heitor (2013), “How far university global partnerships may facilitate a new era of international affairs and foster political and economic relations?”, Technological Forecasting and Social Change, 95, pp. 276-293.
developments, as well as levels of institutional diversification and related risk-sharing mechanisms to foster skilled job creation; and iv) the need to better characterize participatory processes of R&D agenda setting to help engaging scientific structures with the civil society.

The analysis is presented in light of the need of a **stronger connection between the measurement of S&T and related policies and policy instruments**. This is because Governments spend money, but usually there is very little data on the role policy instruments play in the whole system, as well as of the quality of the design and implementation of policy instruments. The question that I would expect to raise from the 3rd OECD Blue Sky Forum is what type of comparable indicators could be constructed?

To answer this question, the analysis presented in the following paragraphs suggest that most of the work currently performed by the two OECD directorates dealing with research and education (i.e., STI and EDU) should attempt to better integrating their activities towards the development of a next generation of research and education indicators. This is very relevant from the policy-making perspective, because governments need better data to assess institutional reforms, which do require an integrated view of skills, research and innovation.

### 4.1 Measuring the limits of quantification: the need of intervention on research assessment practices and scientific and academic career development paths

Since the last Blue Sky Forum in Ottawa, 2006, a set of major international declarations and movements have been promoted worldwide to call for new policy actions about the need to give priority to changes in research assessment practices and, above all, in scientific and academic career development paths. Two distinct but related questions should be considered by the OECD and national statistic offices to help characterizing best practices and avoid the misuse of data.

First, I refer to the misuse of indicators in research and career assessment, particularly bibliometric data and impact-related factors. It calls for a major action worldwide to guarantee that research assessment practices and, above all, scientific and academic career development paths are based on a thorough discussion of the scientific activity content, complying with international standards and respecting clear and transparent rules recognized by the scientific community. The related impact in research and higher education assessment relates to the need to give credibility to the practice of independent scientific assessment, excluding irresponsible and uncritical use of metrics for evaluation purposes.

Although this debate has started in the nineties, only in recent years the need to promote further reflection has been effectively recognized, as a result of excessive proliferation of ill-informed and misapplied metrics. This has been clearly addressed in a set of major international reports and declarations, including the San Francisco Declaration of 2012, the Commission Recommendations on Self-Regulation in Professional Science of the German DFG in 2013, and the Leiden Manifesto of April 2015. The principles set out in these documents


42 DORA. It was initiated by the American Society for Cell Biology (ASCB) in December 2012. It is a worldwide initiative covering all scholarly disciplines, presently signed by 611 organizations and 12.764 individuals. An analysis of available data on individual DORA signers as of June 24, 2013 showed that 46.6% were from Europe, 36.8% from North and Central America.

43 Recommendations of the Commission on Professional Self-Regulation in Science, published by DFG – Deutsche Forschungsgemeinschaft in 2013, as an update of the 1997 recommendations of an international commission appointed by DGF, German Research Foundation following a case of scientific misconduct, "with the mandate: to explore causes of dishonesty in the science system, to discuss preventive measures, to examine the existing mechanisms of professional self-regulation in science and to make recommendations on how to safeguard them.”

emphasize the importance of peer review and best practices based on an integrated and responsible vision of research contents.

For example, the Leiden Manifesto is clear in that “‘Quantitative evaluation should support qualitative, expert assessment. […] Assessors must not be tempted to cede decision-making to the numbers. Indicators must not substitute for informed judgement. […] Both quantitative and qualitative evidence are needed; each is objective in its own way. Decision-making about science must be based on high-quality processes that are informed by the highest quality data.”

Also, the Commission Recommendations on Self-Regulation in Professional Science of the German DFG have clearly noted “Since publications are the most important ‘product’ of research, it may have seemed logical, when comparing achievement, to measure productivity as the number of products, i.e. publications, per length of time. But this has led to abuses like the so-called salami publications, repeated publication of the same findings, and observance of the principle of the LPU (least publishable unit).”

In addition, following the San Francisco Declaration, which was signed by today’s most influential scientific organizations “Challenge research assessment practices that rely inappropriately on Journal Impact Factors and promote and teach best practice that focuses on the value and influence of specific research outputs.”

These observations certainly call for action at the level of the OECD statistics, namely to change current methods of presenting research productivity measures, as well as to discuss emerging theoretical advancements for the analysis of research results and their impact.

By definition, indicators can be used but also misused45, like any other type of knowledge, and the OECD is the most relevant world institution to acknowledge this and foster better observation and assessment practices. It is a necessity to examining the lessons learned over the last few years in different contexts and countries, in particular when indicators are used for the evaluation of research and higher education. It is in this context that a major contribution of the OECD would be highly relevant for policy making in order to avoid inappropriate decisions on research assessment practices and scientific and academic career development paths.

It should be noted that the emphasis considered in OECD and many other statistics worldwide in bibliometric data is promoting misuses and fallacies. The societal implications are not only the potential injustices suffered by research workers, but also—and mainly—the fact that the eviction of the assessment of the substantive quality and its replacement by the virtual quality assumed by questionable metrics, is usually reinforcing the status quo in scientific paradigms and makes it more difficult for new and critical ideas to reach the surface.

A second related issue is the growing concern towards “open science”, and the need to ensure that results from scientific research are available, read and used as a basis for future research as well as for their recovery and incorporation into the social, economic and cultural fabric46. It is a concern that reflects, on the one hand, a democratic view of disclosure and access to science and, on the other, the desire to know and to promote academic and non-academic impact of research.

The issue is relevant for OECD statistics because analysis over the last decade confirmed that the progress of scientific and technological knowledge is a cumulative process, depending in the long run on the widespread disclosure of new findings. For example, Paul David47 has consistently shown that “open science is properly regarded as uniquely well suited to the goal of maximizing the rate of growth of the stock of reliable knowledge”. As a result, research and

45 See Giogio Strili (2005)
academic institutions should behave as “open science” institutions and provide an alternative to the intellectual property approach to dealing with problems in the allocation of resources for the production and distribution of information.

Although the debate on the impact of research assessment practices is relatively recent, requiring therefore a prudent approach, there are already funding institutions and evaluation systems that seek to respond to these new challenges\textsuperscript{48,49}. The principle of open access to published research results, including articles in journal and monographs, considers the free access online the most effective means of ensuring that the fruits of research financed by public funds are accessible to all. On the other hand, the basic principle of access to research data and databases, which requires lengthy methodologies that can also involve more complex ethical issues, should be the object of reflection and a broad debate.

Third, recent evidence suggests that “evaluating scientific impact using short citation windows by focusing only on the most prominent journals may fail to recognize the value of novel research,”\textsuperscript{50} The risk, therefore, is that by promoting researchers and providing incentives to publish and be cited in the top journals may itself slowdown the pace of aggregate scientific discovery. This, again, reflects a bias towards the “economic impact” or “instrumental value” of science, but based on heuristic and simplistic perceptions of the value of harnessing the creative spirit of humanity to fulfill our common humanity – which will also generate economic and other benefits over the long run. The current practice almost inverts the causal impact of science on well-being by providing preserve incentives that work against fully leveraging our creativity and ability to advance scientific inquiry.

Overall, I would expect, as a result of the 3rd OECD Blue Sky Forum, completely new indicators on unexplored themes of research and career assessment practices that could better guide future policy making in terms of the limits of quantifying knowledge, in the true spirit of a “blue sky initiative”. The OECD could conduct a survey, discuss new indicators by bringing together sociologists and scientists and develop a user manual. In addition, a new set of indicators to quantify good practices should be planned, together with the need to avoid the use of current impact-related indicators.

4.2 New data on migratory flows influencing science and innovation: the case of Europe

In the context of identifying emerging factors affecting research and education that require new data sets, this section attempts to revisit the issue of migratory flows from two different and complementary perspectives, considering the European landscape in recent years as a case study.

First, the globalization of the economy, the increasing international competition for qualified human resources and the rapid increasing numbers of highly skilled people moving across the globe have completely changed the profile of migration: the ratio between the migration of people with lower skills and the migration of high skilled people, which is no longer an elite and relatively restrained type of migration, is much more balanced than in the past.

As a result of this process, it is well known that the technological leadership of many industrialized countries and regions (notably, the east and west coasts of North America, but also UK, Germany and many industrialized regions of Europe) continues to be built in substantial part on the contributions of foreign-born scientists and engineers, both permanent immigrants

\textsuperscript{48} Finch J et al, (2012), Accessibility, sustainability, excellence: how to expand access to research publications.

\textsuperscript{49} See also, ERC Work Programme 2016; HEFCE Statement of Policy: Policy for Open Access in the post -2014 research Excellence Framework, 2014

\textsuperscript{50} http://www.nber.org/digest/jun16/w22180.html
and those staying in the country only for a time. This clearly affects the spatial distribution of skilled people and calls for better policies to balance brain circulation in many world regions. For example, the case of Europe in recent years shows a fast moving geography of knowledge, which requires to be assessed and of concern of policymakers.

Second, increasing migratory flows and forced displacement worldwide occur as an unintended consequence of events (like wars and natural disasters) that move highly-skilled people, often turning them into refugees. In recent years, a massive inflow of refugees from conflict regions was directed into Europe and this should consider priority actions in science and innovation policy making.

Although these two issues derive from totally different rationales, they are increasingly global and becoming very timely in Europe and can be framed in a way to better promote science and innovation and their impact in society and the economy. The ultimate goal is to guarantee the provision of official data on migratory flows that lead the adoption of consistent and comprehensive national and global actions for responsible science policies, together with the increase of the attractiveness of S&T for the new generations.

It should be noted that migration is complex, dynamic, and far from self-contained. It has amplified the platforms of far-right and populist parties across Europe, become a key issue in US politics and has even precipitated the referendum in which the UK decided to leave the European Union. Curiously, however, a recent report of the Migration Policy Institute clearly suggests that anti-immigration sentiment is not reliably correlated with either large-scale increases in the foreign-born population, high unemployment, or economic downturns, as often assumed. The only possible exception is national security/terrorism.

The related policy implications are so important for the years to come that, again, I would expect, as a result of the 3rd OECD Blue Sky Forum, completely new indicators on migration of skilled workers, in the true spirit of a “blue sky initiative”.

In this regard, “incentives” are a key issue that needs to be addressed from the point of view of measurement. This is because people migrate because in most cases they found better incentives in better environments and innovation friendly ecologies. Getting better data of the nationalities of the people moving might be connected with the nature and quality of our national institutions, and our ability to retain talent (i.e., not only with salaries, but with stable creative environments).

To help deepening the analysis, the paragraphs below focus on Europe because the capacity of R&D public and private institutions to make Europe attractive to youngsters, knowledge workers and related investments depends on new policy frameworks that also consider capacity building across the entire Europe and beyond, including in conflict regions. The continuous qualification of the workforce at large is a persistent challenge that requires broadening the social basis for advanced education, as well as for further internationalization of knowledge and innovation networks.

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This is the time to call for a common approach to science, innovation and migration and call on all stakeholders to work together in the development of a comprehensive set of actions to attract human resources for knowledge and foster brain circulation for all.

It should be noted that the levels of accumulated investment per researcher in Europe is still about 50% lower than in the USA and that the average investment in R&D per citizen in Europe has decreased comparatively to that in USA\textsuperscript{53}. In addition, only those European nations that have increased the investment in S&T and managed, at the same time, to diversify their economic structure have fully guaranteed the necessary absorptive capacity to foster the impact of S&T in economic development. Consequently, research and innovation policy formulation in Europe, after a decade hit by recession and economic and budgetary problems, must take into account countercyclical measures to adequately account for emerging migratory flows of skilled people, while focusing on advanced education of human resources and strengthening research and innovation in all branches of knowledge.

4.2.1 Balancing brain circulation and intra-European migratory flows of skilled people

Research mobility is an important element for social and territorial cohesion at a European scale. Hence, a healthy distribution of the R&D personnel may play an important role to decrease the gap between the EU28 and other advanced regions.

Under this context, it is well known that the recent financial crisis had a number of far-reaching implications for the European Union, and one of these has been the way it has impacted intra-EU mobility of researchers and skilled workers. Although precise numbers have not been registered yet, there are clear indications that crisis-hit European countries have been experiencing significant emigration flows. This is because one of the most relevant impacts of the decreasing political support to education, science and technology over the financial crisis of recent years in Europe and has been the emerging migratory flows internal to Europe.

Despite the lack of accurate data on the migration qualification structure, Figure 1 shows the substantial growth of migratory flows from Southern to Western and Northern Europe since 2010, mostly of qualified young people\textsuperscript{54}. The respective impact on the reduction of the scientific and technological capacity in Southern and Eastern European regions and peripheries is not quantified or described, but has been recurrently debated by the scientific and academic community.

For example, the level of support for attracting young researchers from abroad to work in Portugal and Spain (among other countries and European peripheries) has been considerably reduced. In addition, the argument of overqualified personnel and the related reduction of the level of support for advanced education have re-emerged the debate on the sustainability of doctoral and post-doctoral studies in Spain and Portugal\textsuperscript{55}, in a context of growing international competition for qualified human resources\textsuperscript{56}.

\textsuperscript{55} Heitor, M., Horta, H. and Santos, J. (2015), Why training PhDs?, Technological Forecasting and Social Change, accepted for publication.
Within a framework of high volatility of a fast-changing society and economy – as it always has been – and at a time where increasing socio-economic inequalities are observed throughout Europe, one should conclude (perhaps counter-intuitively) that the system must go on expanding and diversifying in order to meet the quantitative and qualitative needs of the future. The analysis must consider the need to cover an increasing diverse population, the demands of society and of volatile and highly uncertain markets.

It is, however, reasonable to ask what has changed in Europe in the last decade? In addition to the number of graduates in science, technology, engineering and mathematics per 1,000 inhabitants, where European peripheries (and Southern European countries in particular) underwent the most significant changes within the framework of the OECD, the reinforcement
of formal qualifications is confirmed as a distinct feature of some of those countries (e.g., Slovakia, Poland, Czech Republic, Romania and Portugal).

For example, in Czech Republic and Portugal the number of researchers in working population grew by about ten times between 1982 and 2012 (namely from 0.92 to 9.23, in terms of the number of researchers per thousand working population in Portugal). About 45% of researchers are women in Portugal and the number of researchers in companies was about a quarter of the total number of researchers in 2012 (it was less than 10% in 2000, but exceeded ten thousand researchers in FTE in 2012). In addition, advanced training of human resources, as measured in terms of new PhDs per 10,000 inhabitants has considerably improved throughout European peripheries.

Nonetheless, this scenario contrasts with the overall levels of qualification when measured in terms of the working population. Figure 2 quantifies the evolution of the percentage of working population (aged between 25 and 64) with tertiary education in science and technology fields or of those with a professional activity in which qualifications in science and technology are usually claimed to be held (i.e., “Human Resources in Science and Technology” or “HRSTO” in technical literature), which shows a considerable and persistent deficit in Southern and Eastern European regions over the last decade. For example, whereas in the United Kingdom, the Netherlands, northern European countries and in Europe’s most industrialized regions, the HRSTO accounted for more than half of the workforce, that percentage in most southern and Eastern European regions remains below a quarter of the workforce (namely 24% in Portugal in 2012).

The analysis suggests that the outflow of high-skilled individuals faced particularly by Southern and Eastern European countries in the last years, may have significant negative long-term implications for Europe at large. Actual migration trends –with remittances tending to fall and mobility of the highly skilled rising– enhance distances between core and peripheral European regions, due to the net and systematic losses of highly skilled and especially young people for the latter. This means working together in policies to invigorate the attractiveness of investments in education, research and innovation institutions in the periphery, which are systematically facing the centrifugal forces affecting their actual and potential human resources. These policies should be a concern at the EU level, since the ‘brain drain’ process among Member States –which systematically transfers resources from economically less developed to more developed regions– is not a process that individual countries with persistent losses can or should face on their own.

It is under this context that our analysis suggests that the design of future policy frameworks require the annual and systematic provision of official data on migratory flows of highly skilled human resources among EU Member states as well as between Member states and third countries. The ultimate goal is to foster the public debate leading to the implementation of mechanisms to foster brain circulation amongst Member States, balancing internal EU migrations, as well as for boosting the attraction to Europe of highly qualified scientists, making use of European Structural Funds. Although the analysis above is concentrated in Europe as a case study of emerging migratory flows affecting research and education policies, it should be clear that migratory flows are greater in other parts of the world. For example, the systematic provision of official data on migratory flows of highly skilled human resources is also a recurrent issue in North America and worldwide, namely in the context of policy making to facilitate regional innovation clustering. This has become a “commonplace” in many national and regional contexts, but one that has also been shown to be far from to be effective.
In fact, many clusters and regional initiatives have been reported in the literature, but their effective assessment and evaluation is very scarce and rather modest. It should be noted that “artificial” (i.e., top-down) regional innovation clustering policies are given for granted, but they are far from being a success everywhere.

Regional innovation dynamics and clustering effects have been studied in the technical literature for a few decades and related policy implications are clearly not immediate. For example, Steven Klepper\textsuperscript{57}, a world-renown economist, has recently shown for the case of leading industrial clusters that all began with a single seed. In particular he has shown that “in semiconductors and cotton garments, the seed was the main catalyst for the growth of their clusters, whereas in autos and tires other successful firms related to the seed also catalyzed the growth of their clusters. Change no doubt played a critical role in the seeding of each of the clusters and thus their location. Subsequently, though, the evolution of the clusters followed a similar path. The

movement of employees from the initial seed(s) to new firms either founded or shaped by the employees propagated the original seed(s).”

The findings have complex policy implications because they suggest that “the mobility of workers who possess valuable tacit knowledge plays a key role in the creation of new firms that propel industries forward”. Certainly this mobility can also weaken incumbents, so it is a double-edged sword. But the overall mobility of workers seems to have been key to the tremendous growth experienced in each of the clusters.

This quite naturally raises the question as to whether government and public policies could be productively used to plant such seeds deliberately. That is a far-reaching question that cannot be easily answered. Following Klepper, “at least in the case of the semiconductor industry, the military was the largest customer early on for advanced semiconductor devices, which proved to be instrumental in the success of Fairchild Semiconductor, the seed for the Silicon Valley semiconductor cluster. While the military had its own objectives, it is instructive that the semiconductor industry and the Silicon Valley cluster certainly owes its success in part to a government entity.”

In addition, recent research at Carnegie Mellon has clearly provided new insights into the implications of the nature of the technology on the design of policies and programs for regional innovation dynamics. Quoting Kowalski (2012), “if the technology is relatively open or able to be disseminated in ways that do not require direct experience, regional cluster development strategies focused on existing producers with related experience may be appropriate and effective. However, in the case that knowledge is complex and tacit, and complementary assets of existing producers are not valuable, these strategies may need to be modified to rely more on mechanisms that expose potential entrepreneurs to direct experience with cutting-edge technologies.”

This research shows that the development of regional industrial clusters cannot be seen as a one size fits all approach: what works for one region or one industry may not be effective in another setting. This is because “...any efforts to build regional clusters when knowledge is complex and tacit may benefit from facilitating employee mobility in the form of spinoff firms, especially the mobility of those individuals working at high quality firms who possess the most valuable product, market and management knowledge. While the elimination of non-compete agreements is one approach to increasing mobility, other approaches such as increased networking opportunities or seed grants to fund start-ups among individuals with previous industry experience may also yield positive results. Important to this approach, however, is that access to the appropriate leading edge knowledge is vital in the creation of successful firms.”

The analysis shows that labor mobility and related regulatory frameworks may have a key impact on the process of industrialization and, above all, on the geography of knowledge and innovation. For example, Cheyre et al (2012) has recently shown that “the greater mobility of semiconductor inventors in Silicon Valley was due primarily to spinoffs and not the clustering of the semiconductor industry there or California’s ban on the enforcement of employee non-compete covenants. To the extent that greater inventor mobility benefited Silicon Valley semiconductor producers, the benefits were mainly experienced by entrants and not incumbent producers.”

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This is important because it suggests that public policies to promote skilled mobility need to be carefully adjusted. The traditional agglomeration economy externality may not be true everywhere, anytime.

4.2.3 Science in Europe and the refugees: Research and Higher Education in Emergencies
We now turn to the complementary issues of migratory movements of refugees and the way science and innovation data can drive new policies to give priority to such movements in a way that emphasizes the impact of science in society.

In recent years, a massive inflow of refugees from conflict regions was directed into Europe. Refugees have mainly been channeled towards Southern countries as their entry point, and their number largely increased, leading almost to two million asylum claims by mid-2016. Apart the difficulties to handle the recent migrant wave, it should be acknowledged that there are particular opportunities for win-win policies and results related to the human resources it contains.

These opportunities are easier to produce in Europe due to its culture of tolerance, which enables to embrace and work with diversity. Many of these refugees are young women and men, who were forced to interrupt their studies and/or research in the origin countries and are willing to pursue their advanced formation and foster their starting careers. International mobility cooperation and exchanges are integral to the academic system. European Research and Higher Education Institutions are used to host foreign students and scholars and they are able to develop emergency academic responses. Channeling highly skilled refugees to education and research institutions will contribute to assist refugee integration.

On the other hand, the European experience in setting-up SESAME in Jordan is calling further actions to promote the unique role European scientists and their institutions, together with science diplomacy, can play to foster research capacity and science for peace in conflict regions in the Middle East.

European academic and research communities should be encouraged to work together in the development of a contingency plan to help continue research and education through the establishment of a solidarity instrument which will facilitate a dynamic and swift relocation process, ensuring that the refugees will have reception and integration support in line with international and European standards, as well as to start planning long term strategies to help building research capacity in conflict regions.

It is also under this context that our analysis suggest that the design of future policy frameworks requires the enlargement of a “Rapid Response Mechanism for Research and Higher Education in Emergencies” (following the experience of http://www.globalplatformforsyrianstudents.org/), in order to create and fund a fast track entry point for specific target group of refugees, students and scholars who belong to communities and/or countries at risk in need of humanitarian assistance. The ultimate goal should consider promoting the public debate leading to the implementation of a long term plan to help building research capacity in conflict regions in the Middle East and other regions.

Again, the social, economic and political implications of these processes are so important for the years to come, that completely new indicators on the mobility of skilled refugees, together with those on research and education in emergencies, as well as with the characterization of the potential role of “science for peace”, should be considered by the OECD as an outcome of the 3rd OECD Blue Sky Forum, in the true spirit of a “blue sky initiative”.

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4.3 New data on research practice, players and intermediaries promoting science, innovation and socio-economic resilience

It is clear that technoglobalism and the globalization of trade and supply chains led to the emergence of increasingly competitive global markets and to facilitated access to new suppliers, independently of their geographic location (Berger, 2005). This has allowed countries and regions with strong technological and industrial bases to profit on the lowering of trade barriers to access new markets, while the majority of firms located in other regions remained confined to local markets.

In addition, the analysis of the overall trend on moving towards knowledge intensive services and its relation with job creation and economic growth requires some pragmatism. This is because, in parallel to technoglobalism came post-industrialism, promoting services as the new developed countries’ economic growth overtaking manufacturing industries. Captivated by the prospects of accelerated and cost-effective economic growth, many countries, the United States included, started shifting their focus from manufacturing industries to knowledge-intensive services.

The result is emerging with many regions worldwide lagging behind. Looking at the most developed economies, including US, Germany and the Netherlands, we can identify some common factors, but also opportunities that need to be understood in international comparative terms: strong science and R&D bases, diversified economy, and supply chain and knowledge networks’ complexity.

At this stage we should remember that the primary economic rationale for a government action in R&D is that, absent of such intervention, the private market would not adequately supply certain types of research and skill development. The argument, which applies particularly strongly to basic or fundamental research, is that the full economic value of a scientific advance is unlikely to accrue to its discoverer, especially if new knowledge can be replicated or disseminated at low cost.

For example, James Watson and Francis Crick received a minute fraction of the economic benefits that have flowed from their discovery of the structure of DNA. If many people are able to exploit, or otherwise benefit from, research done by others, then the total or social return to research may be higher on average than the private return to those who bear the costs and risks of innovation. As a result, market forces will lead to underinvestment in R&D from society’s perspective, providing a rationale for government intervention.

But it is not a trivial matter to understand the processes that enable investments in R&D and human capital to be transformed into productivity gains. Actually, there is a widespread view among economists that this kind of investment is too costly for the economic efficiency gains it provides.

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60 Berger, S. (2005), “How we compete – what companies around the world are doing to make it in today’s global economy”, Doubleday Press.
For example, Sebastian (2016)\(^69\), among other economists, suggests that achieving an education system of high quality through an increasing investment might not be a solution to the low efficiency of the Spanish economy. Heavy expenditures in education have yielded poor results in terms of economic growth in some countries and there might be an asymmetry between productive structures and education; whereas the productive structure can pull education up, the latter cannot push the former. Sutton (2005)\(^70\) argues that the main driver of growth is the gradual buildup of firms’ organizational capabilities, while others in the technical literature assert that successes of Germany and Switzerland, whose exports are among the most diversified and sophisticated in the world, are often credited to the rigor and practicality of their basic education systems.\(^71\) Related specialized literature also suggests that technological development and higher education are more effective in generating growth in upper middle- and high-income countries, whereas secondary education and political institutions seem to be more important for low-income countries.

This however is a too naive and superficial approach. Viewed from a wider perspective, in the longer term R&D and human capital investments do matter and are probably the most important factor in explaining economic growth. However, the naive view has a point: the transition of human capital to growth it is not automatic. Specific actions are needed to make this transition happen successfully. Again, the policy implications of these processes are so important for the years to come, that completely new indicators should be considered by the OECD as an outcome of the 3\(^{rd}\) OECD Blue Sky Forum, in the true spirit of a “blue sky initiative”. To help achieving these goals, new theoretical advancements are necessary and the OECD could conduct a survey, discuss new theoretical advancements and develop a user manual.

Within this context, it should be noted that the literature is clear in that economic development and its relation with R&D are increasingly understood as a combination of learning processes, at all levels: individual, organizational, and national.\(^72\)\(^,73\)\(^,74\)\(^,75\). Thus the challenge is to understand why and how some people, firms, and countries learn, while others do not. Diversity and heterogeneity across individuals and countries will always surely entail some level of inequality in learning performance. Still, the dimension of the gaps and the size of OECD (and world) inequalities warrant a search on the reasons why some do learn so well, while others seem to lag, even acknowledging for the idiosyncrasies that will always lead to some differentiation across individuals, organizations, and countries.

When focusing on regional and national learning, the first question to address is who are the actors of the learning processes and how the knowledge that is accumulated is translated into economic wealth. Learning at the aggregate level of a region or country is likely to depend on many types of learning at different levels, from people to organizations. But it should also be clear that this has been perhaps the argument mostly used in many OECD and European countries to reverse policies and/or reduce investment in S&T since 2011.

It should be clear that the time lag for investments in knowledge creation to impact on the economy and the efficiency in transferring research results to the productive system are two key related variables to achieve growth. Inefficient expenditure will necessarily imply longer economic growth times. The combination of these factors, insufficient time and inefficiency, also

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reflects economic structures in a process of adaptation still with relatively low absorptive capacity, reliant on low wage, poorly qualified human resources, low-value economies and innovation cycles, and limited knowledge-based entrepreneurship in many OECD regions and countries\textsuperscript{76}.  

For example, the analysis described above of Sebastian (2006) for Spain\textsuperscript{77} suggests that the efficiency in spending R&D budgets depends on the nationally established political, social and economic practices “of cronyism, legal insecurity, deficient administrative organizations and poor regulatory patterns, deep-rooted values in the Spanish society, which create an unfavorable framework for efficiency and entrepreneurship and set more restrictions to the economic transition to an advanced production model than the shortcomings of the human resources trained in the current educational system”. Simultaneously, a renewed effort to sustain investments in knowledge and integrate it to upgrade and diversify the economic structure is essential, including engaging the business sectors in global value chains. It should be clear that numerous developing countries have achieved growth for a certain period (usually, less than a decade), but have been unable to sustain it\textsuperscript{78}. Rodrik (2006)\textsuperscript{79}, for example, stresses the importance of sustaining rather than simply initiating growth.

Approaching these questions requires the continuous and systematic “observation” of various aspects, including:

- The geography and dynamics of knowledge and economic development, together with levels of specialization – how scientific, technological and industrial bases evolve and impact socioeconomic development.
- The structure, geography and dynamics of supply chains and knowledge networks in different sectors and markets.
- Policy tools to foster local innovation processes (e.g., public expenditure in R&D and training, public procurement, local production agreements,).
- Industrial transformation processes, characterizing them and identifying, analyzing and governing related risks.

It should be clear that a new generation of industries will drive the economic recovery over the next decade, fuelled by long-term investments in research and education, together with changes in technology, society and geopolitics. The recession has not been only a point of change, and many argue that it has acted as a catalyst for growth. As the business landscape alters, we will see the emergence of new ways of doing business in an increasingly educated and interconnected world.

It is under this context that the following paragraphs briefly present two main areas for new data sets to better characterize emerging issues in science and innovation, with emphasis on research practice, players and intermediaries promoting science, innovation and socio-economic resilience.


\textsuperscript{77} Sebastian, C. (2016) España estancada. Por qué somos poco eficientes, Galaxia Gutenberg.


4.3.1 Strengthening “practice based research” and implications for science and innovation policy: promoting inclusive innovation and training students for new jobs

This section focuses on professional practice based research and argues about the need for new theoretical advancements leading to a user manual to be developed by the OECD, together with a potential future revision of the Frascati Manual.

Professional practice based research is research conducted by practitioners for practice purposes and the advancement of professions. Following Dodd and Epstein, it considers relatively simple modes of systematic inquiry that will inform and improve professional activities and the understanding of the work by professionals. It is not “Rocket science” and while the research itself maybe relatively simple, the reality in which it is conducted and to which it is applied is usually very complex and dynamic.

It is well known that most of the existing STI indicators result from the professional R&D laboratory and the activities of the industrial science and technology (S&T) system as it emerged over the late nineteenth and twentieth centuries. In other words, over the last fifty years, STI statistics acknowledged but did not quantified a broad spectrum of scientific and technological services (STS) linked not just to R&D but also to production and other technical activities in both efficient innovation and the diffusion of technical change in many branches of industry.

However, in our fast changing societies, promoting inclusive innovation everywhere and anytime, together with the education and training of the labour force is facing new challenges worldwide as productivity growth and wealth creation needs to experience new boundaries. For example, despite the efforts of national governments to foster regional innovation systems and to increase participation in higher education, almost two-thirds of the adult population in Europe are still lacking skills that would make them successful in innovation-driven environments. These skills consist of a number of technical competencies and “soft” skills, including leadership, teamwork and efficient self-regulating competencies. The scarcity of this type of “skilled” labour force is not uniform and, for example, has been identified in many Southern European zones and other European peripheries, either in the service sector or in manufacturing.

The scarcity of skilled workers has often been attributed to, among other things, the considerable gap between educational systems and companies’ needs, or to the fact that learning and training profiles are not suitable for current industry settings. The relative mismatch between jobs and skills has also been recently addressed by Osterman and Weaver in the context of North America. The authors claimed that there is a need for “intermediaries”,

that is, institutions that can help match employer needs and training, and, at the same time, argued for the increasing relevance of non-university higher education.

We refer to technical, professional and vocational higher education, such as “Polytechnics” in Portugal, “Fachhochschulen” in Germany and Switzerland, “Hogescholen” in The Netherlands, or “Community Colleges” in US. The term “Universities of Applied Sciences”, as it is also referred to in Europe, is not intentionally used to highlight the rationale for fostering diversification of higher education and for strengthening professional and vocational (i.e., non-university) higher education.

It should be noted that Australia and the United Kingdom abandoned a binary system in favor of a unified system of higher education and introduced forms of market competition in education, in order to produce a more diverse higher education system. The fact that the education market is not perfectly contestable and education is a positional good, explain the failure of these policies and the relative lack of specilization of their professional higher education.

For example, analysis of the Australian evidence shows that competition in a market environment type leads to stratification of the higher education system, with a relative emulation of the most prestigious research universities by the other institutions, instead of producing diversity at the institutional level91. The net result is that the less prestigious institutions, rather than seeking a diversified solution, tend to imitate the success of institutions in the search for financial rewards both.

Also Shatock92, regarding the similar situation in the UK, notes that the attempt to use a competitive internal market in a period of rapid growth to give universities greater freedom to create more individualized missions did not succeed. The dominance of the cultural impact of research assessment exercises called research quality to the better funding discouraged the emergence of alternative models in a period of financial rigor.

It should also be noted that, regarding the diversification of higher education, shaping the educational curricula in accordance with industry is, however, problematic (and often not recommended) since skill requirements are not easily definable. Approaching this issue requires a clear identification of relevant skills, rather than simply quantifying the skills of jobholders in a given occupational field. This calls for a common language between employers and training institutions and the development of intermediary functions in training institutions to match the educational supply with the needs of industry93.

In addition, analysis suggests that strengthening problem-based learning and short-term project-oriented research through technical and vocational higher education can facilitate the process of training the workforce in skills of increasing relevance to local markets94. This can be facilitated if training is built around collaborative research, with external stakeholders engaged in the social and economic landscape of the regions under analysis. The process benefits from collaborative ties between the stakeholders and the practitioners of technical and vocational higher education, in particular when training is supplied together with a systematic engagement of practice based research.

Learning and training practices are increasingly research-based and, above all, inclusive of social and economic partners via formal and, most of the time, informal collaborative mechanisms.

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These occur, above all, as an opportunity for strategic action at organizational and content levels.

Overall, the need for a clear but synergistic division of labour at the regional and national levels among universities, high-level vocational training encompassing research-based training, and industry and service businesses, stresses the idea of the “entrepreneurial university” referred to above in this paper was problematic because it worked if fact against the need of this institutional diversity. And the need to have this diversity at the regional and national levels is imperative if we want to avoid a world excessively segmented functionally, which necessarily leads to excessive social and territorial imbalances, inequalities and forced movements.

Again, the policy implications of these issues are enormous and should require the attention of the OCDE statistics, within the context of a true “blue sky” initiative. For example, recent analysis in Europe derived from initiatives to strengthen the research-teaching nexus in the Hogescholen sectors in Flandres and the Nederlands has identified three potential necessary conditions for policy making towards the modernization of technical and vocational higher education, if the external context and absorptive conditions are adequate:

i) the human dimension (it has always been relevant in any educational setting), particularly the specific role of human intermediaries supporting learning/research methodologies, and particularly Problem-based Learning approaches. This requires involving teachers and business experts, together with other social stakeholders and specific research staff, as the central elements of active learning systems;

ii) the institutional research context necessary to facilitate highly specialized knowledge, namely, in the form of practice-based research units that provide a professional context adequate to foster the necessary routines to collaborate with industry and society at high levels of specialization;

iii) the external environment and funding conditions, which do certainly depend on specific local and national ecosystems and are particularly influenced by the overall funding level for research and development in the regions considered.

The development of professional practice based research may be economy- or policy-driven but occur as an opportunity for strategic action at organizational and content levels. It may strengthen the institutional credibility of technical and vocational higher education by engaging local external actors in training the labour force. In addition, it may help to stimulate the necessary institutional and programmatic diversification of research and higher education systems.

Within this context, I would expect from the 3rd OECD Blue Sky Forum a movement towards theoretical advancements in the theories that inform us how to better frame professional practice based research. It is clear that the links and the differences between applied research and practice-based research should be better understood from a methodological point of view. In other words, I do not think professional higher education should be limited to do applied research, highly specialized in nature, if they have the capacity to do so, but the focus should primarily be on practice based research. Ideally, practice based research should be conceived as a part of professional and vocational higher education curricula, not an isolated institutional activity or a part of the optional course.

It is under this context that our analysis suggests that the design of future science innovation policy frameworks require the annual and systematic provision of official data on “practice based research”. The ultimate goal is to foster the public debate leading to the implementation of mechanisms to foster diversified learning profiles and training practices, which are

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increasingly research-based and require the validation of diversified research practices together the adequate characterization of “professional practice-based research”.

Overall, changing the patterns of teaching and learning, making students’ work more active, and fostering student-centered education schemes, are the ultimate goals of many leading institutions, which should be better understood at an overall level. We need to allow students to determine their own learning paths and trajectories, particularly through education cycles, but also across institutions in different regions and countries.

The debate requires tertiary education institutions in general to better understand how people learn. It is clear that learning systems vary considerably across the full spectrum of disciplines, with arts and medicine using project-based approaches and, probably, engineering and the social sciences following a more intense academic drift. The recent book by Tony Wagner96 of Harvard, as well as that published last year by Douglas Thomas and John Seely Brown97, represent insightful treatments about this theme.

Again, the relevance for OECD statistics is that it would imply a better framework for a correct analysis and characterization of “practice based research”. This requires the design and implementation of correct observation and assessment tools, which should consider the following reference terms:

- **Professional development**: Stimulating deepen the knowledge of professions and their evolution through practice-based research, including research lines defined in collaboration with economic, social or cultural partners;
- **Context**: multidimensional and interdisciplinary, pointing to different outputs, reporting on developments in professions;
- **Scope**: focusing on local issues and organizations of society, but international relevance;
- **Integrated with the participation of students**: fully integrated in educational/learning programs, involving teamwork and practical research and encouraging peer review;
- **Methodological Rigor**: ensuring the dissemination of rigorous methodologies to solve problems and provide solutions, properly validated and ethically acceptable.

To help achieving these goals in terms of the recognition of professional practice-based research, new theoretical advancements are necessary and the OECD could conduct a survey and develop a user manual. Then, a new category of research in a future revision of the Frascati Manual should be discussed.

4.3.2 Articulation with intermediaries and emerging stakeholders

We now turn to articulating innovation policies with key stakeholders beyond large industrial sectors and briefly address the role of intermediary institutions. Their role in determining innovation policies requires the systematic provision of official data on their activities and impact, together with the dynamics of government-industry-science relationships.

Many international comparative assessments include specific recommendations towards launching major public programs to support and fund institutions of the type of the German’s Fraunhofer Institutes, the Dutch TNO, or the recently formed CATAPULT institutes in UK and the CARNOT Institutes in France, as well as many other similar institutions elsewhere. This remains to be better framed and understood, because all those institutions are very much framed in local and specific contexts, including direct relationship with specific national stakeholders.

Under this framework, a key issue that needs to be understood is that the processes that enable investments in R&D and human capital to be transformed into productivity gains are NOT a trivial matter everywhere. Specific policies and actions are needed to make this transition happen successfully.

The notion that intermediary institutions are the solution to many current policy questions may no longer suffice. New skills requiring intense and effective direct contact between advanced industries and different institutional stakeholders are essential and increasingly utilized. Linkages between different parts of the system will now require assimilating, sharing, acquiring and creating knowledge. Firms seek for access to knowledge in higher education institutions and research centers. Higher Education institutions, per se, search for collaborations, contracts and agreements with businesses. Students are employed and trained by industry. Entrepreneurs, innovative agents, knowledge producers, researchers, academics, and students are connected in a process of knowledge producing and sharing.

The challenges for policy are enormous and require new and adequate data sets. First, what can be done at the level of the political and regulatory systems to provide the necessary incentives to effectively elevate and broaden the overall level of technological leadership, as well as to foster absorptive capacity? Second, what can be done at the regional and national levels to establish and sustain international learning networks and trajectories that can lead to wealth creation and the required entrepreneurial capacity allied to new scientific competences and training needs?

To attempt answering these questions, we need to consider ‘framework conditions’, ‘rules of the game’ or ‘institutions’, depending upon the specific technical literature and how systems approaches are considered. Nevertheless, I would argue that emerging forms of technological change involves complex industry-science relationships, which include but do not seem to be confined to traditional forms of international commerce in services. This new model may derive its uniqueness from the very nature of the various parts to be involved. Beyond the continuous need to foster the integrity of academic communities, it looks very important to promote intermediaries (including engineering and technology centres over a range of different areas of knowledge) and technology-based firms. They act as critical players in potentially new forms of any innovation strategy.

The approach considered in this paper builds on two main lines of thought. First, large networks have been very interesting and relevant, but they are not effective in promoting change. Network competitiveness depends on many factors, requiring increasingly focused partnerships. Large international collaborative arrangements play an emerging role and should be promoted through new regulatory frameworks.

Second, the science and technology performance sectors – government, industry and academia – remain key players, but the connectivity links, and associations with other organizations are no less important. In particular, the increasingly relevant role played by intermediaries and technology-based firms is identified. These are also becoming global and require opening up science and innovation policies to multiple public and private agents and promoting global research networks towards socio-economic resilience. Above all, it requires framing future innovation policies in terms of the need to foster and promote a network of technology suppliers and skill-intensive employers.

Ultimately, the sustainable development of our societies requires a new phase of innovation policy that gives priority to skilled employment. Again, intermediaries and technology-based firms play a critical role in this process but require continuous incentives to diversify their activities beyond a single market. The related implication is the need for public policies actively promoting the internationalization of those players.
Within this context, I would also expect from the 3rd OECD Blue Sky Forum a movement towards theoretical advancements in the theories that inform us how to better frame institutional diversity in the emerging research landscape.

4.4. From the public understanding of science, to participatory R&D agenda setting

My final issue is about how far the provision of new data sets can influence policies to foster harmonized developments of large and fully integrated knowledge-based societies? We refer to forms of promoting the active and direct involvement of people at large to discuss scientific research needs and contribute to promote effective investments in knowledge production and diffusion through participatory processes.

In other words, I would argue that we need to evolve from the stimulus to the public understanding of science, to the active participation of citizens and major stakeholders in R&D agenda setting. And this requires the attention of OECD statistics to guide policy actions towards the adequate development of participatory processes.

Following Latour’s (1988)\(^98\) principle of “science and technology in action”, our analysis suggests the need to better engaging scientific structures with the civil society, in order to position future experiments towards collaborative policy making and science governance through dialogue. This may include the involvement of scientific communities in ‘hybrid forums’ (Callon, et all, 2009)\(^99\), where scientists, policy makers and lay people meet to agree the purpose and appliance of scientific knowledge in decisions where uncertainty is at stake. Our hypothesis is, therefore, associated to the concept of "indwelling" firstly introduced by Polanyi (1966)\(^100\) and recently explored by Brown and Thomas (2011)\(^101\) in the context of the "information society". It requires a better understanding of learning societies and policy formulation issues through complex processes of knowing, playing and making.

Philosopher of technology Andrew Feenberg\(^102\) has also stressed the importance of democratic participation in technology decisions through his critical theory of technology, that challenges the technocratic claim that only the experts can usefully contribute to the design and employment of technology: "the experts and the public are in communication now whether they like it or not". Feenberg argues that we need to learn "with the wisdom gained by living with technologies and their impacts. In a modern context, this cannot be accomplished by tradition but requires a more democratic technological regime. The gradual extension of democracy into the technical sphere is one of great political transformations of our time\(^103\).

For example, Hordijk and Baud\(^104\), among others, have shown that scientific research can play a more integral role if it is carried out as part and parcel of the urban governance process. This requires participatory processes of research agenda setting with local citizens, a research practice that recognizes and makes explicit the value of localized types of knowledge, and a changed role for researchers themselves from external experts into resource persons in the urban governance process. There is a need to combine different ways of producing knowledge,

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103 Feenberg, A., "Tecnologia, modernidade e democracia", Org. e trad. Eduardo Beira, Inovatec, (Portugal), 2015
104 M. Hordijk, I. Baud (2006), "The role of research and knowledge generation in collective action and urban governance: How can researchers act as catalysts?", Habitat International 30, 668–689.
ranging from scientific knowledge, practice-based knowledge and local citizens’ knowledge, to enable different actors to work together in improving urban, regional and national governance and collective actions to tackle critical issues worldwide. Broadening the types of actors participating in local policy formulation and giving legitimacy to knowledge other than ‘expert knowledge’ overturns the current patterns through which urban development is channeled and existing power relations in countries, regions and cities.

Also, collaboration with patients in healthcare and medical research is an emerging development and, for example, Abma and Jacqueline Broerse (2010) 105 developed a methodology for health research agenda setting processes grounded in the notion of participation as dialogue. Patient involvement in research agenda-setting aims to increase the quality and legitimacy of the research policies of funding agencies and to stimulate research on topics considered important to patients. Worldwide, various health authorities have experimented with involving patients in research agenda-setting 106.

In addition, the work of Ilan Chabay and co-authors, among many others in stakeholder- engaging research and participatory processes in climate change and sustainability provides evidence of the need to better conduct and expand such processes. This is because, environmental governance is increasingly turning away from classic top-down hierarchical governance regimes and experimenting with more collaborative forms of governance, including analytic-deliberative participation of resource users. For example, Stohr and Chabay (2015) 107 examine the role of the Polish Baltic Sea Fisheries Roundtable as a multi-stakeholder platform in Polish Baltic Sea fisheries governance. The fisheries sector within a country rapidly transitioning from a centrally planned system to (pseudo) market conditions provides an illustrative case in a very difficult context. Employing an action- and learning-based approach, we participated in the initiation and institutionalization of a process of levelling the playing field and building trust within the fisheries sector in Poland.

If we try to develop further the implications of participatory processes for research agenda setting and the terms which must influence the formulation of urban, regional or national science and innovation policies, it is obvious that three vital issues must be addressed: a) scale, especially when it comes to the undeniable need to increase public efforts in science and innovation; b) diversification, namely regarding the need to perceive the difference between instruments and the role of public and private funding; and c) time, regarding the need to understand a continued effort in science and innovation.

But the design of science and innovation policies for the future will also gain from the fact that the last decade has been particularly stimulating in helping us understand the need for improvement over the usually assumptions about economic development, and, instead, putting more emphasis on what else determines how consumers behave: the inertia of habits, the importance of default options on decision making, and more generally, the effect of how information is presented, and why human behavior so often follows the pattern of fast thinking/pattern recognition rather than slow, effortful, analytical thinking (Kahneman, 2011 108).

Kahneman’s experiments with two groups of patients undergoing painful colonoscopies are very inspiring. Group A got the normal procedure, while Group B — without patients being told — had a few extra minutes of mild discomfort after the end of the examination. Since the prolonging of Group B’s colonoscopies meant that the procedure ended less painfully, the patients in this group retrospectively minded it less. As with colonoscopies, so too with many other actions and decisions in life. It is the remembering self that calls the shots, not the experiencing self.

Also in recent years, Thaler and Sunstein (2009)\textsuperscript{109} argue about the increasing relevance of nudge and the way individuals are influenced by their social interactions. Nudge takes our humanness as a given. Knowing how people think can help designing choice environments that make it easier for people to choose what is best, at both individual and corporate level.

But, in addition to that argument, we argue for a deep discussion about the complexity of stakeholder engagement and the politics of trust building in science and technology in OECD countries.

This is because, beyond any single measure, one may argue that it is the public engagement in scientific activities, beyond the already traditional understanding of science and the related level up to which people trust in academic and scientific institutions, that determines the success of the politics of science and innovation policies. In other words, I would argue that the systematic development statistics about activities to foster science awareness, science education and the role of science in the daily life of citizens, as implemented in many regions and countries and quantified by OECD thorough levels of science literacy, is not enough any more.

Today we need to go further and promote participatory R&D agenda setting processes. It is under this context that our analysis suggests that the design of future science policy frameworks require the annual and systematic provision of official data on participatory processes for research agenda settings and practice.

Again, I would expect from the 3rd OECD Blue Sky Forum a movement towards theoretical advancements in the theories that inform us how to develop statistical information about participatory R&D agenda setting processes in a way to foster future policies promoting such processes. It is clear that this goes far beyond the task usually assumed by indicators developers and the OECD could conduct a survey, discuss new theoretical advancements with institutionalists, psychologists, sociologists, scientists and, finally, statisticians and, then, develop a user manual.

4.4.1 Forward looking

The issue is certainly how far we all take advantage of opportunities that arise with the increasingly dynamic and globally distributed geography of research and education, as well as how it fosters a new global order and help others to use similar advantages at local levels.

This is because one must take up the challenge of probing deeper into the relationships between knowledge and the development of our societies at a global scale. Our inspiration comes from, among others, the seminal work of Lundvall and Johnson\textsuperscript{110}, who challenge the commonplace by introducing the simple, but powerful, idea of learning. Lundvall and Johnson speak of a “learning economy”, not of a “knowledge economy”. The fundamental difference has to do with a dynamic perspective. In their view, some knowledge does indeed become more important, but some also becomes less important. There is both knowledge creation and


knowledge destruction. By forcing us to look at the process, rather than the mere accumulation of knowledge, they add a dimension that makes the discussion more complex and more uncertain, but also more interesting and intellectually fertile in an international context.111

This closely follows the lessons Eric von Hippel112, at MIT, has provided in recent years based on the American experience that user innovation is a powerful and general phenomenon. It is based on the fact that users of products and services - both firms and individual consumers - are increasingly able to innovate for themselves. It is clear that this is growing rapidly due to continuing advances in computing and communication technologies and is becoming both an important rival to and an important feedstock for manufacturer-centered innovation in many fields.

Eric von Hippel has also shown that the trend toward democratization of innovation applies to information products such as software and also to physical products, and is being driven by two related technical trends: first, the steadily improving design capabilities (i.e., innovation toolkits) that advances in computer hardware and software give to users; and second, the steadily improving ability of individual users to combine and coordinate their innovation-related efforts via new communication media such as the Internet.113

In other words, beyond suitable technical infrastructure, the process of “democratization of innovation” at a global scale requires people with the ability to engage in knowledge-based networks without borders. It is about people and knowledge beyond national borders, and this constant interaction has gained particular importance in recent years.114

It is clear that the emerging patterns of innovation require new perspectives for public policies, which in the US and in EU have in the past relied on supporting manufacturers and their intellectual property.

Certainly we need to move on from those days and consider better ways to integrate policies, as well as to diversify them at a global scale to better consider “win-all” approaches. A potential way to achieve this is to avoid overemphasizing current rival sectors and competitive strategies, but rather to look at science, education and innovation policies towards new challenges that require a strong collaborative and pre-competitive approach.

Long-term challenges, namely those with current direct implications for firms (large and small), researchers and higher education institutions include the emerging opportunities associated with the democratization of human genome sequencing and the emergence of personalized medicine throughout the world, as well as the increasing convergence between health sciences, physical sciences and engineering.115 But also sustainable energy systems worldwide should be a subject of priority for government intervention and innovation policies with a great potential for global impact.116

In this regard, and following the emerging discussion about the future of S&T, it is clear that, by and large, the financing of higher education and of science and innovation has occurred along rather traditional lines. Yet, the history of science is rich with varied means of financing science

and technological innovation. More importantly, developments in the size, integration, and technologies available in global capital markets present the opportunity to think about new financing possibilities and processes of societal engagement in S&T policies. These involve moving from traditional, “one-way” (and most of the time fragmented) government policies, to integrated multi-stakeholder policies involving a wide range of public and private agents.

5. Summary

This paper attempts to enlighten new insights about the need for new and better data to foster informed S&T policy making worldwide. It focuses on research and education and argues about the unique role of OECD S&T statistics over the last fifty years, although the number of indicators has exploded and the pendulum has swung excessively towards the economic dimension. In other words, S&T statistics have moved excessively towards capturing the “instrumental” value of S&T and innovation (i.e., STI) and a rebalancing is required to fully capture the “intrinsic” value of S&T and innovation. At the same time “the link between the measurement of national STI activities and their national economic impact (while always subject to debate, particularly within the context of small countries), has now become so loose that national STI indicators are in danger of no longer providing relevant economic policy insights”.

The paper acknowledges the role of OECD STI statistics having some different dimensions on what governments and policy makers expect from OECD (and its network):

- One is the traditional role of defining “measurement standards” (i.e., Frascati, Oslo and Canberra Manuals), which require continuous work in connection with education and skills statistics (e.g., “Canberra Manual” on human resources on S&T);
- The second role refers to the compilation of statistical information produced by national statistics offices, based on those Manuals (e.g., MSTI). This requires better addressing the basic issue of the jobs or employment of scientist and engineers to better understand knowledge production and absorption processes;
- A third relevant task, and very important for future global and timely analysis is the role of the OECD in building an “indicators production infrastructure” in STI. By entering directly in “international data collection”, the OECD STI statistics would gain additional relevance, to be supported in panels of “R&D and higher education managers”, “STI policymakers”, and “individual researchers”, making use of online survey techniques to get rapid responses to key questions and to monitor the changes over time.
- Last, but not least, a fourth relevant task is the mission of OECD of teaching and helping the users of indicators to better understand the differences between events and occurrences, or concepts and indicators, that usually measure the reality from a partial point of view.

So, I would expect, as a result of the 3rd OECD Blue Sky Forum and in the time frame of the coming ten years, a thorough revision of OECD STI statistics with emphasis on unexplored but relevant areas of knowledge, in the true spirit of a “blue sky initiative”. In particular, the role of research and education beyond driving innovation for sustainable productive economic growth, particularly in association with a culture of learning and knowledge, as well as driving better public services, improving health, prosperity and the quality of life, and protecting the environment, should be emphasized by OECD statistics.

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Table 1 summarizes our main concerns in terms of the development of a next generation of research and education indicators in a way to help rebalancing and fully capture the “intrinsic” value of S&T. From the “production-side” of indicators, it is expected a debate on the need to open and enrich the production of indicators to consider contributions from a wider variety of scientific backgrounds to better reflect a complex web of impacts that go well beyond economic aspects. On the other hand, from the “user-side” of indicators, theoretical advancements in the theories that inform us how to safely navigate in existing OECD data sets, beyond any further refinements, are also expected.

Table 1. Summary of main concerns towards the improvement of existing research and education indicators in a way to help rebalancing and fully capture the “intrinsic” value of S&T

<table>
<thead>
<tr>
<th>Indicators and their process</th>
<th>Theory behind the indicators</th>
<th>Scope for Blue sky</th>
<th>Relevance to all OECD countries</th>
<th>Key competences</th>
<th>Work to be done</th>
<th>Impact for NESTI</th>
<th>Timing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Production-side of indicators</td>
<td>a lot of indicators available. Requires further theoretical advancements</td>
<td>Review existing practices of devising new indicators</td>
<td>Yes! Also, worldwide</td>
<td>Scientists, philosophers, sociologists, and, finally, statisticians and economists</td>
<td>Review existing procedures and implement new processes</td>
<td>Conduct survey, discuss new processes and develop a user manual</td>
<td>Medium-short term</td>
</tr>
<tr>
<td>“user-side” of indicators</td>
<td>Requires new theoretical advancements</td>
<td>Design new practices of using indicators</td>
<td>Yes! Also, worldwide</td>
<td>Web-designers, psychologists, philosophers</td>
<td>Review existing procedures and implement new practices</td>
<td>Conduct survey, discuss new processes and develop a user manual</td>
<td>Medium-short term</td>
</tr>
<tr>
<td>GBOARD</td>
<td>Requires better comparability of public investment and competitive funding</td>
<td>Review existing practices of estimations</td>
<td>Yes! Also, worldwide</td>
<td>Policy makers, Scientists, and statisticians</td>
<td>Review existing procedures and implement new processes</td>
<td>Conduct survey, discuss new processes and develop a user manual</td>
<td>Medium-short term</td>
</tr>
</tbody>
</table>

In addition, the paper argues (in a second part) that new data sets are required to opening-up science policies to multiple public and private agents and stimulate the continuous adaptation of systems of competence building and advanced studies, among which promoting global research networks should be highlighted.

The OECD statistics should consider the need to foster a non-hierarchical integration of formal policies and informal system linkages leading to knowledge-driven societies, including education, foreign affairs and immigration policies. This requires new data because policy making needs a better characterization of new forms of international cooperation giving priority to science, education and migrations. And new data sets should be able to foster the collective action of governments, institutions and the private sector to promote the diversification of education and research systems leading to technological change, as well as a participatory approach to science and innovation.

To achieve these objectives and help the discussion on the next generation of research and education indicators, four main sets of data that require further refinements, as summarized in Table 2 and briefly described in the following paragraphs:

i) Research assessment practices and scientific career developments, which call for a major action of OECD to characterize those processes and guarantee the adoption of best practices worldwide, including the type of incentives considered;

ii) Migratory flows of highly skilled human resources, which call for a collective action of OECD at large, including for:
a. The systematic provision of official data on migratory flows of highly skilled human resources around the world, including intra-European data, in order to guide policy making to better balance brain circulation and migratory flows of skilled people, including the critical need to better consider and measure incentives;

b. The provision of data on refugees, students and scholars who belong to communities and/or countries at risk in need of humanitarian assistance, in order to stimulate policy actions worldwide to foster a Rapid Response Mechanism for Research and Higher Education in Emergencies;

iii) The characterization of practices and institutional intermediaries to help diversify research and education, including:

a. The adequate characterization of “professional practice-based research” oriented towards professional developments, in order to guide policymaking towards the advancement of professions, as well as training students for new jobs, which requires building distinct learning profiles and training practices that are increasingly problem-oriented and research-based;

b. Official data on institutional diversification, together with data on connectivity, links and associations among public and private institutions and new institutional players and employers and related risk-sharing mechanisms to foster skilled job creation;

iv) The need to better characterize participatory processes of R&D agenda setting to help engaging scientific structures with the civil society.

<table>
<thead>
<tr>
<th>Indicators</th>
<th>Theory behind the indicators</th>
<th>Scope for</th>
<th>Relevance to all OECD countries</th>
<th>Key competences</th>
<th>Work to be done</th>
<th>Impact for NESTI</th>
<th>Timing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Research assessment practices and “open science”</td>
<td>Weak, but a lot of indicators available. Requires further theoretical advancements</td>
<td>Yes, very strong, because it requires devising new indicators</td>
<td>Yes! Also, worldwide</td>
<td>Sociologists, scientists and, finally, statisticians</td>
<td>Review existing procedures and design new observation methods. Consider incentives</td>
<td>Conduct survey, discuss new indicators and develop a user manual</td>
<td>Medium short term</td>
</tr>
<tr>
<td>Migratory flows, balancing brain circulation</td>
<td>Available indicators are not enough.</td>
<td>Yes, because it needs to go beyond launching new data collections on the basis of established methodologies</td>
<td>Yes, but worldwide</td>
<td>Demographers, philosophers and statisticians</td>
<td>Review existing procedures, set up new surveys and design new observation methods. Consider incentives.</td>
<td>Conduct survey, discuss new indicators and develop a user manual</td>
<td>Short term</td>
</tr>
<tr>
<td>Professional Practice-based research and Institutional role of intermediaries</td>
<td>Requires new theoretical advancements</td>
<td>Yes, because it requires new ideas</td>
<td>Yes! Also, worldwide</td>
<td>Institutionalists, psychologists, sociologists and, finally, statisticians and economists</td>
<td>Define the very concept and the sources of information to build indicators</td>
<td>Conduct survey, discuss new theoretical advancements and develop a user manual</td>
<td>Medium short term</td>
</tr>
<tr>
<td>Participatory processes for R&amp;D agenda setting</td>
<td>Requires new theoretical advancements</td>
<td>Yes, because it requires new ideas</td>
<td>Yes! Also, worldwide</td>
<td>Institutionalists, psychologists, sociologists and, finally, statisticians</td>
<td>Define the very concept and the sources of information to build indicators</td>
<td>Conduct survey, discuss new theoretical advancements and develop a user manual</td>
<td>Medium short term</td>
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</table>

The ultimate goal is to facilitate opening-up science and innovation policies to multiple public and private agents and promoting global research networks towards socio-economic resilience. For example, promoting large international collaborative arrangements and related
intermediaries should play an emerging role in job creation and forms of sustainable brain circulation. In addition, diversifying the research and education systems may promote the necessary absorptive capacity for regions to innovate.

This certainly requires evolving from national approaches to new collaborative policy frameworks, which need to be driven by informed public debates and require the systematic characterization of levels of knowledge concentration and openness, in times of increasing uncertainty.

This is because, traditionally, OECD STI statistics report at the “country level” comparisons and, more and more, there is a need to create resources and databases on “organizations” that could be compared. The “Community Innovation Survey, CIS” on firms innovation behavior is an example, but the OECD could encourage the creation of basic indicators at the level of other organizational actors (e.g. higher education institutions, or public research organizations across countries), that could really allow for comparison.

In addition, an important conclusion of the analysis presented in this paper is that most of the work currently performed by the two OECD directorates dealing with research and education (i.e., STI and EDU) should attempt to better integrating their activities towards the development of a next generation of research and education indicators. This is very relevant from the policy-making perspective, because governments need better data to assess institutional reforms, which do require an integrated view of skills, research and innovation.

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