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Europe's Future:

Open Innovation Open Science Open to the World

Reflections of the RISE Group

Research and Innovation

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Europe's Future: Open Innovation Open Science Open to the World

Reflections of the Research, Innovation and Science Policy Experts (RISE) High Level Group

March 2017

"[First,] our actions must always reflect European values of openness and diversity, if we are serious about using European research and innovation for something greater than our own gain. [And second,] we have to embrace change – try new things and be willing to take risks – if we want European research and innovation to remain at the forefront of modernity and economic growth."

Carlos Moedas[1]

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[1] European Commissioner for Research, Science and Innovation. The quote is from Lund Revisited: Next Steps in Tackling Societal Challenges, Lund, 4 December 2015.

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TABLE OF CONTENTS

Foreword 6

Commissioner Carlos Moedas

RISE High-Level Expert group 2016 8

Executive Summary 10

Chapter 1: On the impact of research and innovation: untapping the potential of openness 19

1.1 Introduction 21

1.2 The impact of openness on economic growth: an overview of the debate 22

1.3 Open innovation, the diffusion of knowledge and productivity growth 28

1.4 The diffusion deficit and economic convergence 35

1.5 Digitalisation of the Knowledge-Innovation nexus 46

1.6 Policy Implications 55

Chapter 2: Open Science 57

2.1 Introduction 59

2.2 Open science: A framework to foster quality of research 60

2.3 Funding and Career Advancement in an Open Science Environment 65

2.4 Scholarly publishing and peer-reviewing in open access 73

2.5 Open Data: Challenges for implementation and possible solutions 82

2.6 Open Science and Research Integrity 87

2.7 Policy Implications 92

Chapter 3: Open to the World ... 95

3.1 Introduction ... 97

3.2 Science, Technology and Innovation for Sustainable Development ... 99

3.3 Science Diplomacy ... 106

3.4 Tools for Science Diplomacy in the EU ... 113

3.5 Policy Implications ... 118

Chapter 4: Open Innovation: the need for a new policy narrative ... 123

4.1 Introduction ... 125

4.2 Open innovation: An emerging and increasingly important topic ... 126

4.3 The European Innovation Council: strategic reflections ... 130

4.4 Pro-Innovation Regulation ... 145

Chapter 5: Conclusions and Policy Outlook ... 155

5.1 Introduction ... 157

5.2 The 21st Century productivity paradox ... 158

5.3 Broad policy challenges ... 159

Appendices ... 162

Appendix 1: The Mallorca Declaration on Open Science ... 163

Appendix 2: Funding Mechanisms: A Case Study on Translational Oncology ... 165

Appendix 3: Climate-KIC: a knowledge innovation community ... 181

References ... 197

Acknowledgements ... 221

FOREWORD

FOREWORD

There is no doubt that science and innovation are playing an increasingly important role in shaping Europe's future. For Europe to maintain its leading position in fundamental research, cutting edge innovation and addressing global societal challenges, openness is a pre-requisite. Without openness, research and innovation will not be able to reach its full potential, serve our citizens and ensure a sustainable, dynamic economy and a better society for generations to come.

I am grateful to the members of RISE High-Level Expert group for the thoughts and ideas that contribute to my political agenda of Open Science, Open Innovation and Open to the World. Not only does it show the extent of their expertise and understanding of the complex reality in which research and innovation interact, it will also provide valuable input for the further development and implementation of Europe's research and innovation policy.

I encourage readers to engage in a broad reflection and debate throughout Europe on the economic and societal policy rationale for an open EU Research and Innovation strategy. This book illustrates how we can improve productivity of our R&I investments and helps us design instruments for research and innovation to drive a dynamic European project.

Carlos Moedas
European Commissioner for Science,
Research & Innovation

RISE HIGH-LEVEL EXPERT GROUP 2016

RISE gives strategic advice to Carlos Moedas, the European Commissioner for Research, Science and Innovation, on aspects related to the formulation and implementation of policies under his remit. The strategic advice focusses on improving the framework conditions for research and innovation and contributes to the articulation of the Commissioner's Open Innovation, Open Science and Open to the World agenda. Furthermore, RISE also provides insight in optimizing the contribution of research and innovation to smart, sustainable, and socially inclusive economic growth for the EU within a globalized world.

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EXECUTIVE SUMMARY

The focus of the analyses presented in this book is on the way open science, open innovation and open to the world – the so-called 3 O's – are likely to impact European innovation performance, growth and international competitiveness. As the quote from Commissioner Carlos Moedas cited above highlights, research and innovation are essential for Europe's long term future. Given Europe's demographics and the global competition to attract talents, to produce scientific knowledge, to create new value, to address – and find solutions to – the many social, economic and environmental problems, a readiness to "embrace change", to "try new things and be willing to take risks" will be essential for Europe to keep its unique position in the world as beacon of "*values of openness and diversity… using European research and innovation for something greater than our own gain*".

This book has been written following the suggestion from Commissioner Moedas to the Research, Innovation and Science Expert group (RISE), a group of some 30 experts from different nationalities, with different backgrounds and a wide spectrum of fields of expertise, to reflect on the challenges European research and innovation policy has been, and will continue to be confronted with, in an out-of-the-box fashion: suggesting and proposing where needed concrete proposals for policy action. The "out-of-the-box" nature of those reflections imply to a certain extent that the views and opinions, as presented here, not necessarily represent full consensus views amongst all RISE experts. It is also the reason why the contributions are individually authored. Rather in presenting those reflections we hope to feed the debate at the Commission but also in Member States (MS) on the challenges for European research and innovation policy in the rapidly changing environment of digital, global connectivity and collaboration in science without borders; the emergence of radical new models of innovative value creation with sometimes little connection or reliance on (industrial) research activities; and the hope and expectation that science and technology will be there to provide solutions as much at the global level – think of the sustainable development goals, but also science diplomacy – as at the local city level – think of smart cities and circular economy principles – to find responses to the major grand challenges Europe as well as the rest of the world is being confronted with.

From the outset the focus of these reflections have centred on the 3 O's: a challenging concept launched by Commissioner Moedas back in June 2015 and which has been the subject of many debates amongst the research community, policy makers and the business community. Of course the concept of 3 O's provides a neat structure, one which we follow also here, to sometimes rather narrow technical debates about green versus gold open access or disruptive innovation and regulation, but the common concept of "openness" behind the 3 O's provides, certainly in the current environment of rising populism and fact-free opinion sharing in social media, a particularly welcoming unifying notion, pulling together all those involved and motivated by knowledge creation – from the fundamental research side to the new sharing economy user – of being open: open to others, to foreigners, to participation, to sharing. In this sense the concept of the 3 O's as launched by Commissioner Moedas, appears certainly with hindsight, a particularly welcome principle to govern Europe's research and innovation policy.

Exploiting fully the advantage of having a large group of RISE experts at one's disposal, the discussion amongst experts has been organized over the last year alongside each of the three O's with three subgroups of experts addressing respectively Open Science (OS), Open Innovation (OI) and Open to the World (OW), and a fourth group: Open Knowledge

Markets (OKM), consisting primarily of economists, addressing the broader issue of the impact of the 3 O's on economic performance. Openness, new things and the willingness to take risks are, however, concepts which are difficult to fully capture in economic analyses, let alone integrate in economic models attempting to correctly measure and estimate the impact of a more open research and innovation environment on economic growth and international performance.

It is the reason why we start in a first Chapter with some of the broader economic reflections of the OKM RISE group focusing in particular on the impact of research and innovation, and in particular the potential impact of the 3 O's. Any discussion on the impact of research and innovation must start today from the puzzling economic evidence that today, just as thirty years ago, there is conflicting evidence on the trend in the growth, or rather the lack thereof, of productivity: the "core" variable in any econometric analysis on the impact of research and innovation on growth and welfare. Indeed, just as in the 80's when this lack of evidence was referred to as the "productivity paradox", following a side remark of Bob Solow's review in the New York Times Book Review of Stephen Cohen and John Zysman (1987) book: "... what everyone feels to have been a technological revolution, a drastic change in our productivity lives, has been accompanied everywhere, including Japan, by a slowing-down of productivity growth, not by a step up. You can see the computer age everywhere but in the productivity statistics." (Bob Solow, 1987). As often, viewed retrospectively, a lot has been learned from research analyzing that paradox, paying attention to historical similarities. Thus, there is now broad agreement that more attention needs to be paid to the role and importance of the diffusion of new, "radical" technology not leading immediately to productivity gains but often only after a lag related amongst others to a first phase of declining capital productivity (David and Wright, 1999); the even more essential need for organizational changes to exploit fully the often, in first instance, unnoticed efficiency gains associated with the new technology (Freeman and Soete, 1987, David, 1990 making the comparison with unit electric drive); the role of skills and on the job learning and more broadly the balance between the race between schooling and technology (Tinbergen, 1975), etc. And while some of the evidence on the impact of Internet and ICT on the economy started to become more visible in the late 90's and 00's, it appears today as if the productivity paradox never left us (Acemoglu et al., 2014): the more recent period seems again characterized by lack of formal econometric evidence on productivity growth in most OECD countries. And again this holds today for not only Europe but also the US and Japan. So much so that critics on the radical nature of the new digital technologies, such as Robert Gordon (2012, 2016), have for years now been claiming that contrary to policy belief, there are no radical technologies today leading to major productivity gains compared e.g. to what most economies witnessed in previous centuries with the invention of electricity, the motor car, or the computer.

In short, the fact that productivity growth is actually slowing in most mature, developed countries remains an interesting puzzling feature in the debate on the current digital transformation. As Millar and Sunderland (2016) point out in the case of the US: "in a period where not only many new technologies are being introduced, more firms and countries are integrated into global value chains, workers are more highly educated than ever, it remains surprising that productivity growth is not rising. For sure the financial crisis may be part of the explanation, but OECD data show that productivity growth has been slowing since the early 2000s in Canada, the United Kingdom and the United States" (Sunderland, 2016). It is actually the gap in productivity growth between global frontier firms and the other more domestically oriented firms which raises questions as to the ability of the most advanced firms nationally to adopt new technologies and knowledge developed by such global leaders, and for the firms trailing them at national level to catch up. In a recent speech, the OECD Secretary General, Angel Gurria, put it as follows: "It's clear that the knowledge and technology diffusion "machine" is broken" (2016).

For Europe, compared to both the US and Japan, the gap is even more significant, as illustrated in the persistent business R&D deficit in Europe compared to those countries. As Reinhilde Veugelers (2016), one of the RISE experts points out: "The central economic question here is: *What explains this business R&D deficit? Why does Europe's business sector have less innovative capacity on average when compared to others like the US, despite examples of top performers? And why is this deficit so persistent?*" And we would add here: what is the link with openness, or rather the lack thereof? Could it be that some parts of Europe's business sector have been living in a too "closed", too cosy, sometimes even "zombie" environment resulting from an unfinished single market in may service areas crucial for digital technologies applications. After all, Europe witnessed probably the slowest emergence of a digital union in the world and the fragmentation of innovative procurement at national level remains characteristic for the EU.

It is the core of the analysis presented in the first Chapter of this RISE book.

The second Chapter addresses the first of the three O's: the one which could be considered as the most supply-side and institutionally determined one because primarily dependent on policy action. It focuses on the intrinsic need for Open Science, and the conditions under which it could become a hall mark of European research. For RISE, Open Science is a new way to address the challenges of a sustainable economy resting on three key aspects: Open Access, Open Data and Open Source. Europe, with its excellent research and knowledge base, has a great opportunity to become a leading player. However, to fully implement Open Science one will need to identify the hurdles that currently stand in the way. The RISE Open Science group focused on four key issues and barriers concerning Open Science: a framework to foster quality research; funding and career advancement; publishing and open access; and last but not least research integrity. Furthermore for a fifth key topic – Open Data – an external expert was asked for a contribution. The RISE group identified a number of key issues impeding the implementation of Open Science in Europe.

First, there is the current funding climate for research with its low success rates and the lack of PI-driven (single beneficiary) research funding. It is impossible to select "best" proposals when success rates are so low. The RISE Open Science group comes up with a number of detailed proposals to obtain more meaningful assessments of the content and quality of an individual's scientific output, more PI-driven funding as opposed to large-scale collaborative projects, simplification of granting schemes with general adoption of two-stage application processes and the elimination of grant deadlines.

Second, for the RISE Open Science group science cannot be truly open because publishing is currently dysfunctional. Access cannot be considered open when many of the peer-reviewed journals, publishing platforms and bibliometric tools are owned by major commercial publishing companies. Again some specific recommendations are made whereby publication becomes part of the continuum of research, led by scientists using public publishing platforms serviced, but not owned, by the commercial sector, endorsing the Green Open Access/ self-archiving model, with an Open Access 'button' as the most flexible solution to test different business models before more optimal solutions (such as Diamond Open Access) can be designed and adopted.

Third, Open Data is a key component of Open Science. However, many researchers do not have either competence or confidence in the practice of Open Data. Competence in working with data, establishing appropriate infrastructure, and creating a supporting culture for openness will be the three core challenges for Open Data. For the RISE Open Science group there is a need to develop training programmes to adopt best practice for data management skills, for increasing awareness of the data repository options that exist, for measuring and rewarding data reuse, and funding even explicit data and software career tracks.

Fourth, RISE experts are concerned about the extent to which the understanding and practice of research integrity is variable across Europe. It is proposed that the ALLEA-ESF Code of Conduct should be made binding for all EU countries, and for countries receiving EU research funding. This standard should be supported by the development of experiential training programmes specifically tailored for early and senior researchers – to create the culture within which research integrity for Open Science can flourish.

Realigning European funding, support for Green Access, and creating the conditions for Open Data and Research Integrity – with the goal of an Open Science culture of excellence – will not only encourage Open Science practice within Europe, it will also improve research conditions and enhance Europe's attractiveness for top researchers. This is a chance for Europe to lead a global shift towards Open Science culture that promises to positively impact the acceleration of discovery and innovation worldwide.

The third Chapter brings together the reflections of the RISE experts' discussions on the issue of "Open to the World". The chapter formulates some overarching policy options. For Europe, more than any other region in the world, it is vital to be "Open to the World" particularly in a period when the openness of the world has itself become a matter of contention. Many of the challenges that citizens face at home and across the globe require active and effective international collaboration and the harnessing of state-of-the art science. Global societal challenges are intertwined with local and regional challenges. Local issues, such as failed and failing states or disputes over trans-boundary resources can turn into global threats. Global problems, such as climate change, environmental degradation, water shortages, energy and food insecurities and population changes can translate into local conflicts. To be Open to the World requires insistence on open economies and open societies so as to strengthen human capital and preserve natural capital. In an interdependent, rapidly changing world new threats and new challenges constantly emerge, but also new opportunities.

In the Chapter, the RISE expert group on Open to the World explores the various ways in which the European scientific communities can play their part in addressing global societal challenges. This leads to reflections on how one can better mobilize scientific resources, what should be prioritized, and where the focus of efforts should be geographical. An ambitious plan of action in a context where the European Union is committed to becoming a stronger global actor is proposed. To achieve this ambition means though that one needs to bring together more closely scientific endeavours with the core strands of the European Union's external policies – and it also requires an investment in engagement with partners across the globe. Both the policy communities and the scientific communities will have to develop new ways of working for this ambition to be more than a pipedream.

None of the challenges can be overcome just by hard power – military and/or economic. Politics should not be a zero-sum game; it should be a win-win game. The constructive deployment of science, technology and innovation (STI) can help to increase the likelihood and benefit of win–win games. Therefore, science, technology and innovation are vital "tools" of soft power in the search for mutually acceptable solutions to common challenges. The interplay of STI with policy-making, decision-making, foreign policy and international politics forms the basis for science diplomacy. Together the EU's programs combined with those of the Member States (MS) provide a strong basis for engagement with the rest of the world. Europe accounts for over 30% of the world's scientific production. There are sufficient reason for the EU to make a determined effort to extend the reach and the range of science diplomacy as essential contribution to improving the effectiveness of the EU as global actor. Of course science diplomacy can contribute to but not solve the many challenges by itself. Its deployment needs to be integrated with other tools of diplomacy. However, given the important assets of scientific achievement by Europeans, it would be irresponsible not to develop a more focused strategy for harnessing research and scientific resources more effectively at a global level.

Chapter 4 focuses on the deliberations of the Open Innovation Working Group of RISE. The concept of Open Innovation has of course gained tremendous popularity in both academic and policy circles over the last decade without though fully detailing what is exactly meant by introducing "openness" in relation to a concept such as innovation which is practically by definition representing an intellectually protected, closed notion. The most concise definition comes from Chesbrough (2006): "the use of purposive inflows and outflows of knowledge to accelerate internal innovation, and expand the markets for external use of innovation, respectively." This definition is based on the assumptions developed in the economics and management literature on the role and contribution of "knowledge spillovers". In many cases, organizations will not be able to entirely control knowledge generated internally: some of that knowledge might lead to serendipitous discoveries within the organization, but other might "flow" outside the firm. Until recently and from the point of view of the organization making the investment, knowledge spillovers were considered to be a negative feature because other firms would be benefitting. The key insight from the more recent literature on Open Innovation was that there were gains to be realized in managing these knowledge flows in a more systematic way, hence the term "purposively managed." Thus, firms can develop knowledge transfer processes to bring external knowledge inside the organization, or alternatively develop processes to "export" knowledge and technology, e.g. those that might be considered less useful to core business. Hence the importance of "openness" even within the context of innovation and the extent to which, particularly in the European context, the lack of such openness might have been a factor behind the lack of productivity growth, as discussed earlier.

Where the notion of "Open Innovation" becomes of course directly relevant, is within the discussion of the need for, and the way to implement a European Innovation Council. A key challenge for Europe, given the lack of productivity growth, is how to align innovation policy with the characteristics of the new more open and dynamic innovation environment. This environment, the Open Innovation RISE experts argue, needs different policy tools than those designed in the past. It is critical to establish complementarities and synergies, adaptations and adjustments motivating and pulling in new stakeholders across a number of existing institutions, policy instruments and constituencies. The mission of an EIC has to address these challenges, while providing at the same time an impulse for innovative renewal at all levels of society. The RISE vision put forward is for an EIC that would focus on a few strategic elements, notably building synergies between different EU level instruments for innovation to maximize their added value on the European level, promoting the focus on people, openness and iterative results, and moving towards a new narrative around innovation and innovators.

The third subject discussed in Chapter 4, focuses on innovation-friendly regulation. New types of innovation challenge the way one thinks about regulation. Previously, structured governments interacted with structured companies; now, a decentralized system involving governments, firms and citizens with a high amount of mobility across jurisdictions is emerging and complicating regulatory interactions. In this last section, the RISE OI group presents a variety of reflections on "pro-innovation" regulation: what it means, why the EC might need to further develop and promote this concept, and some general principles on how to approach it. The reader will notice that in this Chapter, the reflections turn out to become more qualitative than quantitative, more forward looking than driven from analysis of the past, more sensitive to inspiring cases and weak signals than by large numbers and average behaviours.

This represents to some extent the red thread throughout this RISE book, as discussed in the final concluding Chapter 5. In this last Chapter we present three sets of policy recommendations following indirectly from the analysis presented in the previous Chapters. First, we emphasize policy measures positioning Europe, as it always was, as open knowledge gatekeeper for addressing societal, global challenges confronting the world as a whole, and Europe in particular. For RISE, the principle of "openness" should ultimately be seen as societies' guarantee to sustainability, as the conceptual framework for addressing the new Sustainable Development Goals (SDGs). Second, we propose policy measures to develop openness as inclusive tool: openness as "commons". The debate on such "inclusive openness" started from within the scientific community with the debate on open science access but includes now also openness with respect to global networks and local communities. Third, we highlight the role of openness with respect to experimentation and regulation. To "embrace change" implies also questioning now and then existing regulation and being open to try "new things", to explore innovation, to elaborate green deals, to test and engage in local co-creation, in living labs of all sorts, in designing experimental areas in cities combining new opportunities for exchanging and extraction value.

The forecast low growth scenario for Europe over the remaining part of this decade is, if the research-innovation axis is not fixed, likely to be accompanied by a loss in competitiveness, with possibly significant job losses even declining welfare in the long run. The full roll-out of the 3 O's should enhance the impact of research and innovation on growth and jobs across the EU. It will have to include policy initiatives that go beyond the simple supply of R&D support and other innovation support policies. Now is time for Europe's future. For Europe to set the direction, leaving the response wide open to the creativity of its citizens, firms, cities, researchers, creating new markets and diffusing knowledge while ensuring a real impact on our economy and society.

Luc Soete, Mary Ritter, Ivo Slaus, Francisco Veloso

Chapter 1:

On the impact of research and innovation: untapping the potential of openness

TABLE OF CONTENTS

1.1 Introduction ... 21

1.2 The impact of openness on economic growth: an overview of the debate ... 22
1.2.1. Introduction ... 22
1.2.2. Knowledge and the innovation system ... 23
1.2.3. Knowledge and the production function ... 24
1.2.4. The role of science in promoting absorptive capacity ... 26
1.2.5. Conclusions ... 27

1.3 Open innovation, the diffusion of knowledge and productivity growth ... 28
1.3.1 Introduction ... 28
1.3.2 Innovation at the frontier and the potential for 'trickle-down' of productivity growth ... 30
1.3.2.1 Competitive pressure on national and European markets ... 31
1.3.2.2 Innovation ecosystems and procurement ... 31
1.3.2.3 Advisory services for the diffusion of technology and innovation ... 32
1.3.3 Conclusions ... 32

1.4 The diffusion deficit and economic convergence ... 35
1.4.1 Introduction: Agglomeration trends and polarisation ... 35
1.4.2. Diffusion of innovation within countries ... 36
1.4.2.1. Absorptive capacity ... 36
1.4.2.2. Related variety in regions ... 37
1.4.2.3. Institutions and good governance ... 40
1.4.3. Diffusion of innovation and economic convergence ... 41
1.4.3.1. The challenge of business R&D and agents of change ... 41
1.4.3.2. Pockets of excellence ... 43
1.4.3.3. Global value chains and digitalisation ... 43
1.4.4. Conclusions ... 45

1.5 Digitalisation of the Knowledge-Innovation nexus ... 46
1.5.1 Introduction ... 46
1.5.2 The creation of global digital markets for the future ... 47
1.5.2.1. Global digital markets and the role of open innovation ecosystems ... 47
1.5.2.2. Key conditions of global digital markets ... 48
1.5.2.3. Open innovation ecosystems in the digital economy ... 49
1.5.3. Detrimental Effects of digitalisation for economy and society ... 51
1.5.4. Conclusions ... 53

1.6 Policy Implications ... 55

CHAPTER 1

ON THE IMPACT OF RESEARCH AND INNOVATION: UNTAPPING THE POTENTIAL OF OPENNESS

1.1 INTRODUCTION[1]

Luc Soete

In this first Chapter, the focus is on the economic impact of research and innovation, a subject which has been the topic of numerous analyses and empirical studies. Measuring that impact, let alone measuring the impact of the policy shift towards a more open research and innovation policy framework, represents, however, a quite fundamental challenge. Challenges at the level of the particular indicators used and the way current growth models incorporate open science and open innovation; the conditions for the diffusion of knowledge and the trickling-down of efficiency gains; the differences in the national and regional absorptive capacity of knowledge, and the incorporation of the digital transformation affecting all sectors, while creating new ones.

To set the scene, the next, second section of this Chapter starts with a short overview at the macro-economic level of what justifies the public support for research and innovation both at national level and European level. The various economic arguments in support of research and innovation are well-known. However, we review those here in quite some detail so as to allow a better framing of what the implications of a further shift towards more "open science", "open innovation" and "open to the world" might entail.

Research and innovation policies in Europe are a shared responsibility between Member States and the EC. The explicit choice for "openness" in governing research and innovation policy at European level, will act as inducement for national policies to follow suit, and is hence likely to enhance the overall impact of such policies. This holds of course in first instance for investments in costly, large research infrastructure such as the ESFRI programme, where Europe has been a frontrunner in being a leading player in providing global scientific communities in different disciplines with new advanced scientific equipment. It also holds for fundamental excellence-driven "frontier research" where the ERC has become in a short period a world leading standard in research allocation, introducing mobility of grants as a "breaking-up tool" of national barriers to research mobility and crossing disciplines with its starter and advanced grants. But it also holds for science, innovation and knowledge investment more broadly, as the subsequent Chapters highlight focussing on the impact of the shifts of European research and innovation policy towards the 3 O's.

In a third section, we move over to the underlying trends at the more micro levels of firms and organizations, where diffusion of technology but also entry and exit are the crucial variables in bringing about productivity growth. The new knowledge-innovation nexus is based on circular flows of both new and accumulated knowledge. Higher productivity levels in a limited number of firms competing in global markets can be diffused in open innovation ecosystems. This requires the creation of new markets responding to societal demand or innovative and expanding fields where users are actively shaping the new solutions. Here, policies can make a difference combining innovative public and private procurement with tools enhancing the capacity of less innovative firms to absorb knowledge.

In a fourth section we reflect on the other engine of European growth: convergence and the geographical impact of research and innovation, taking again into account the potential impact of open science, open innovation and open to the world. Excellent research and innovation is by definition concentrated also in space. Market forces reinforce this geography of innovation, in the EU as well as elsewhere in the world. The analysis explores how new economic concepts such as "related variety" and increased levels of complexity open new ways for analysing the benefits of innovation diffusion across regions and countries in Europe. Once again, this requires a new and more circular nexus between knowledge and innovation, this time anchored in the

1) The Open Knowledge Market RISE group consisted of: Luc Soete (chair), Andrea Bonaccorsi, Ron Boschma, João Caraça, Willie Donnelly, Luke Georghiou, Elyes Jonini, Andrés Rodriguez-Pose, Frederique Sachwald, Lena Tsipouri, Reinhilde Veugelers and Matthias Weber.

physical and geographical world. The identification and strengthening of local actors is important, the absorptive capacity of local firms, but also the way more open universities interact with local and global value chains as emerging 'pockets of excellence'. There is a need here to build on the networking externalities between regional hubs based amongst others on the power of related variety and diversification. And of course, one needs to strengthen the trust building in good governance without which it will be impossible to produce the more complex and competitive solutions. What is at stake is the impact of research and innovation on the economic convergence across Europe.

The fifth section takes this argument one step further. Europe's economy is undergoing a major digital transformation. A new digital layer is transforming the knowledge-innovation nexus in an unpredictable manner, a qualitative change in the way knowledge is valued and used in the 21th century. The merge of digital and physical knowledge platforms is likely to empower more actors in the innovation system, including citizens, cities, social innovation and open government. However, it is a disruption of the current economic model which could slip over to employment destruction or challenge fundamental values and raise major privacy concern. We therefore need the right policy framework conditions to speed up knowledge circulation, capture local value from global innovation chains, and create open knowledge markets where innovation and regulation reinforce each other.

Before turning to the impact and challenges in terms of achieving "openness" in science, as in the next Chapter 2, or in Europe's relationships with the rest of the world in Chapter 3, or in innovation as in Chapter 4, the concluding sixth section draws some overall policy conclusions. It is clear from the analysis presented here, that the new 3 O framework should be viewed in its systemic interaction, in presenting so to say a new policy doctrine to which we will come back in the final Chapter 5.

1.2 THE IMPACT OF OPENNESS ON ECONOMIC GROWTH: AN OVERVIEW OF THE DEBATE

Luc Soete[2]

1.2.1. INTRODUCTION

It has always been difficult to capture the effects of knowledge – and more specifically, scientific knowledge – on economic growth because the likely impact will only fully be revealed in the longer term and because the broader social impact of investing in knowledge goes beyond the various actors: firms, universities, public research organisations (PRO's), etc. initially involved in the investment. On top of this, the process of knowledge generation itself is a complex process – investing more does not automatically mean more or better scientific results and innovation – that cannot easily be described in terms of traditional economic indicators such as inputs (e.g. Research and Development (R&D) expenditures, numbers of Scientists and Engineers) leading to a fixed number of outputs (e.g. publications, patents, new innovations or new products), and even less so to outputs of standard quality. This means that the type of economic models normally used to analyse investment decisions and which today often govern countries' budgetary decisions, are difficult to apply to science and innovation, let alone "open" science and "open" innovation.

When e.g. the EC calculates the effects of its Member States budgets and fiscal policies in its Semester forecasts, it mainly focuses on the short to medium term. Viewed from this angle, the positive effects of investing in knowledge (and other factors) remain largely invisible because they only become evident in the longer term. Public investment in knowledge and research[3] hence mainly impacts expenditure; in other words, increases in government spending. The targeted effect on GDP (and on prosperity in the broader sense) only comes later and remains often imperceptible in the short term, even though for reasons, as we shall argue below, the benefits

[2] This section is partially based on the report of the KNAW (2013) which I chaired. I'm particularly indebted to members of the Commission "Waarde van Wetenschap", and in particular to Peter Tindemans and Bart Verspagen, for their valuable input.

[3] Also in the form of support for private R&D.

appear now and then more immediate, particularly when we consider the knowledge flows associated with the openness agenda.

In this section we discuss in some more detail, the possibilities to quantify the long-term impact of knowledge investment despite the many caveats and difficulties, the extensive literature on macro-economic analyses of technological change has pointed to. For understanding better how the 3 O's might influence the impact of such knowledge investments, it seems appropriate to discuss first this literature. We will focus on two main themes.

The first is the way in which the production function has and can be used as a conceptual framework for modelling and measuring the influence of public investment in knowledge, including European H2020 investment. The second is how we can interpret the different estimates that this method produces. In the latter case, we turn our attention specifically to the importance of "absorptive capacity", a concept which will be central to integrating the 3 O's in our analysis and which will be described in much more detail in the following sections 1.3 and 1.4.

Indeed, "open" science and "open" innovation bring to the forefront the importance of "foreign" science and "foreign" innovation, and at the same time their mirror-images: regional and local absorptive capacity. For the European Union (EU) with its large majority of small Member States (MS), absorptive capacity will be a hugely important factor. Particularly in periods of fiscal consolidation, there might be a temptation to postpone investment in knowledge in some MS, hoping to make up for lost time when the economy recovers. However, if absorptive capacity is not kept up, knowledge accumulation itself will suffer serious erosion, particularly at regional and local level.

We first turn to some conceptual clarifications about the place that knowledge and research occupy in economic theories and models. The shift towards notions of open science and open innovation represents a rather radical change which provides European research and innovation policy with a new and clearer overall framework.

1.2.2. KNOWLEDGE AND THE INNOVATION SYSTEM

It is not only machinery and labour that are important when investing in R&D; another significant – if not the most significant – factor of production is knowledge that was acquired in the past. A researcher makes use of knowledge created previously by her-/him or by other researchers. Different types of knowledge play different roles in that respect. For example, the more theory-driven knowledge from universities is traditionally generated with the specific purpose of making it freely available, more application-driven knowledge generated in a corporate R&D department is often kept secret or commercially protected. The first takes the form of a quasi-public good whereas the knowledge generated by an enterprise can be more readily appropriated to generate new products or processes. The market is only capable of creating and applying part of the knowledge that society requires through privately financed R&D. Government supplements private funding of R&D with public funding of R&D, by subsidising higher education, and with grants or tax facilities to stimulate private R&D.

Because existing knowledge makes the R&D process more effective, the way in which knowledge is shared across the economy influences the effectiveness of R&D investment. One of the aims of publicly funded R&D is to generate input for the private sector, which can use it to innovate and thus increase productivity. In the old linear representation of this process, R&D investment (by the public sector) comes at the start of the innovation process. The scientific knowledge so acquired is then applied by engineers (in the private sector and the more technically oriented universities or high schools) in a specific technology that can be used to meet user needs. Finally, enterprises continue to develop the technology, leading to an innovation (commercial exploitation of the invention). Ultimately, a process of diffusion ensures that the innovation is disseminated throughout the economy, whereupon its effect on GDP becomes tangible and quantifiable.

This linear description of events ignores, however many key aspects of the innovation process, in particular that knowledge generation is often an interactive affair (Kline & Rosenberg, 1986) and that the way in which interaction is organised within the innovation system has a major impact on its efficiency. It are these concepts which are central in the current discussion on the "broken" research-innovation axis.

The participants in the publicly funded segment of the innovation system (universities, public research institutions) have various interactions with enterprises, and these interactions influence both the research agenda and the way in which academics carry out their research. Research is hence pulled by firms' demands in a direction that is not only driven purely by curiosity, and enterprises go in search of scientific knowledge and invest in absorptive capacity to be able to take advantage of external sources of knowledge. In addition, competitors may adopt an innovation and make changes (incremental ones) to it.

Public-sector investment in knowledge thus becomes part of a broader, interactive national innovation system instead of a mere starting point for technological advances. Research becomes intertwined with innovation in this manner, and investment in research plays an interactive system-based role. The theory of national innovation "systems" developed in the 1990s (Freeman, 1987; Lundvall, 1992; Nelson, 1993) analyses how knowledge-sharing works and how it influences national economies. These analyses dispense in many ways with models in which technological progress and innovation proceed according to fixed, linear processes, as often described in growth models. Absorptive capacity – a concept that will be discussed at greater length in sections 3 and 4 – also reinforces this national or even regional system-based role of knowledge. Viewed from this perspective, a significant share of innovation and research policy focuses on interaction, for example technology transfer institutes and measures aimed at encouraging interaction between universities and enterprises. While the concept of "openness" is never explicitly mentioned in those analyses, it will be clear that it plays a central role in the way national innovation systems function.

Thus, as analysed by Hughes and Martin (2012), there are various ways in which semi-public and public knowledge institutions interact with enterprises. They identified multiple channels along which publicly funded research influences innovation and private-sector productivity: making e.g. knowledge available through publications; training graduates who go on to work in firms; universities doing contract research; students or university staff founding start-up companies; and universities and their staff participating in network activities that also involve enterprises. We come back to this in the next section (1.3) where we discuss in more detail the various interactions and their impact on the extent to which productivity "trickles down" from the most productive firms to others.

As the foregoing shows, universities and other publicly funded knowledge institutions play a broad, all-encompassing role as the most "open" science and research institutions. Not surprisingly, they have also been central in the many quantitative approaches measuring the impact of research. One example is e.g. the 'payback framework': a method used in the medical sciences, and more recently in the humanities, to test the outcomes of subsidised research. The payback framework is a case study method that charts in detail the influence of subsidised research and the various additional investments required. The payback framework applied to publicly-funded medical research has shown that such research offers often impressive returns on investment. The payback case studies are interesting because they bring to the forefront that while it is possible to identify the value of academic research, quantification is hindered by the lengthy period of time between a scientific discovery and the first application based on that discovery. And, as would be expected, these studies also show that, in general, the profits do not go only to the investor or country that put money into the initial research, but also, and in particular, to enterprises that apply the technology and to users of their products. These and other methods that attempt to measure the broader usefulness of research do tend to focus on only one or a few projects, putting a more general macro-economic estimation/evaluation beyond the scope of the analysis.

1.2.3. KNOWLEDGE AND THE PRODUCTION FUNCTION

Is it hence possible to map the complexity and dynamism of innovation systems and the effects of "open" knowledge investment on GDP in a quantitative and scientifically accountable manner?

To answer this question, we must start by looking at the voluminous macro-economic literature analysing the influence of investment on economic growth, going back to the simplest example proposed by Nobel laureate Robert Solow (Solow, 1956). The most important element of this model is the production function, a mathematical relationship between production value (GDP) and two factors of production, labour and capital.

How efficient these factors are (how much is produced per unit of production factor) depends on the state of technology – in other words, on knowledge. In Solow's model, knowledge is regarded as totally exogenous ('falling like manna from heaven'). Solow did not take into account that knowledge is generated inside the innovation system and that enterprises and knowledge institutions deliberately invest in knowledge generation.

Initially, the theoretical literature on formal growth models ignored the empirical evidence concerning technology, but in around the late 1980s and 1990s various economists including Paul Romer (1986), Robert Lucas (1988), Philippe Aghion and Peter Howitt (1992) became interested in knowledge and soon found that Solow's exogenous technological progress could be replaced by a model in which investing in knowledge (both human capital and R&D) could drive economic growth. In this 'new growth theory', the production function takes pride of place, as it does in Solow's model. One of the main features of the production function is that capital (plant and machinery) is subject to diminishing returns. Within the context of growth theory, however, the principle of diminishing returns means that in the long term, investing in capital will no longer lead to a higher production value (GDP), and that economic growth becomes impossible. Solow solved this problem by assuming that technological progress would be exogenous.

The new growth models assume that knowledge, as a public good, is non-rivalry (Arrow, 1962), elegantly solving the problem of diminishing returns. Non-rivalry means that a single idea can be used simultaneously by different individuals without diminishing returns. Such non-rivalry ensures that ideas will spread 'like fire, expansible over all space, without lessening their density in any point' (Thomas Jefferson, 1813), in short are "*open*". The new growth models regard knowledge as an extra factor of production. The non-rivalry of R&D investment produces externalities that lead, at macro-level, to increasing returns and so make long-term positive growth possible. It gives a first direct handle on introducing "openness" in production function estimates.

The production function is not only an important theoretical instrument; it has also become the most important empirical tool for quantifying the influence of R&D investment on long-term growth. A voluminous empirical literature is devoted to analysing the impact of knowledge (R&D and education) in this manner. In general, one can identify two approaches to evaluate the impact of investing in knowledge by means of the macro-economic production function:

In the first approach, statistical estimates are used to determine the impact of R&D investment on GDP growth. The estimates can be refined by designing regression equations that involve multiple variables and conditions.

In the second approach, contributions to R&D and other investments that lead to innovation are identified within the context of a pre-determined production function. In this 'growth accounting' approach, an increase in every input is weighted by a factor usually derived from the share that this input contributes to value added.

Regarding regression analysis, there is a considerable body of empirical literature exploring the relationship between R&D and productivity growth (for survey studies see Mohnen & Hall, 2013; Raymond et al., 2013). These studies focus both on the macro (country) and micro (enterprise) levels. One of the key themes in this literature is R&D spillover, or the effects of R&D investment on enterprises other than the investor's own; in short attempting to measure the "openness" of research and innovation. If the regressions concern individual enterprises, then R&D spillover is traced by including both the investor's own R&D investment and that of the other enterprises (as a group) in the regression equation. At macro-level, domestic R&D spill-overs are expressed in the coefficient for total national expenditure on R&D. Estimating international R&D spill-over in these models in turn requires the R&D expenditure of other countries to be included (Coe & Helpman, 1995; Verspagen, 1997). Information on patents (as one of the possible outputs of the R&D process) and data derived from 'innovation surveys' are also used to explain corporate and national productivity growth. Examples of studies that focus on public knowledge investment are Adams (1990), Bassanini et al. (2001), Guellec & Van Pottelsberghe (2004), Coe et al. (2009) and Donselaar (2011). The precise results of these macro-econometric studies appear to depend on how the econometric model is specified and how the variables are defined.

According to the second approach (growth accounting), the contribution of inputs to the production process are traditionally determined by the share of income that they contribute to in the national accounts. This approach clearly has its limitations because the weights are based on assumptions of diminishing returns and constant returns to scale. Both assumptions do not hold true for knowledge in general and scientific knowledge in particular. In addition, it is difficult to show the explicit contribution of knowledge in traditional growth accounting, which normally measures only the contributions of labour and capital. With knowledge as a factor of production, growth accounting must be extended to include the concept of 'intangible capital'. The aim of generating new knowledge involves making all sorts of intangible investment, going beyond education and R&D but including now also design, even advertising expenditures[4]. In addition to the direct contribution that intangible capital makes to growth, it is also of huge importance in boosting the absorptive capacity of the economy (see sections 1.3 and 1.4 below).

The macro-economic regression models that explain GDP growth by pointing to R&D investment offer a good basis for "open" policy analyses. However, the horizon used in such analyses is of crucial importance. Typical budgetary analyses carried out by government finance departments, and at the EC by ECFIN, will cover the short term (the economic cycle) or medium term (a particular Government's policy period), with the main focus being on the effect of certain micro-level policy measures on key economic variables. These models do not include explanatory relationships between knowledge investment in, for example, public European R&D such as national MS' investments in research or H2020 and other intangible assets and GDP. The regression analyses and growth accounting do, however, create scope for public knowledge investment as an explanatory variable of economic growth, with the reason for such future economic growth – i.e. average structural growth over a period of many years – being linked to previous investment in knowledge. We may expect that both growth accounting and regression analysis can help explain the impact of public knowledge investment on the long-term growth of the European economy in terms of GDP, and the shift towards more "open" knowledge exchanges. Growth accounting is excellently suited for ex-post analysis, whereas regression analysis can be used to analyse policy plans. Both methods provide crucial parameters ("elasticities" or rates of return) for translating investment in public R&D or support for private R&D into economic returns.

The macro-economic approach has its limitations, of course. As we discussed before, the projected macro-economic relationship is the sum total of complex processes that play themselves out in the innovation system at micro-level. This sum total does not explain the effects of policy measures implemented at a finer level of detail. In summary: the macro-economic approach does help us understand the long-term effects on economic growth of investing € 1 billion extra in public R&D (or of cutting investment by the same amount), but it offers us no insight into the effects on economic growth of a policy measure that aims to use € 1 billion in existing public R&D funds in a new way, e.g. in a more "open way" or through the creation of new instruments such as in the case of setting up a European Innovation Council (EIC), one of the central proposals of Commissioner Moedas discussed in Chapter 4.

Given the huge importance of knowledge for the European economy, however, it is important that the general tool of macro-economic R&D analysis should be offered to decision makers/policy makers in a clear, transparent way. For example, if we had not invested in the Framework programmes over the last twenty years how much lower would GDP have been now? If this investment had been allocated for example to roads instead of knowledge, what difference would this have made for today's economic growth rate? This is a good way of making the importance and the context of research policy clear and of explaining the choices that feed political and public debate. Ultimately, it is at this level that one should try to get a handle on the impact of the 3 O's: what the impact of a shift towards more open science, open innovation and open to the world would imply compared to a more closed policy framework, something to which we turn now.

1.2.4. THE ROLE OF SCIENCE IN PROMOTING ABSORPTIVE CAPACITY

We know that estimates of the contribution of research to GDP provide also information on the characteristics of the innovation system of the country to which the estimates refer. In the case of the European Union with its huge diversity in size of countries, levels of development, density of population and location of research and innovation clusters, the so-called 'absorptive capacity' of the innovation system will be

[4] Several FP7 projects have recently analysed intangible capital, i.e. INNODRIVE (http://www.innodrive.org/), INTAN (http://www.intan-invest.net/), SPINTAN (http://www.spintan.net/), and COINVEST (http://cordis.europa.eu/result/rcn/53238_en.html). Contact: Dr Marianne Paasi in DG RTD.

a crucially important characteristic. The particular role of absorptive capacity will be an important topic in any policy discussion of the impact of the 3 O's.

A good absorptive capacity will on the one hand be very important for the externalities of investing in R&D and for the diffusion or "trickling down" impacts, it will actually be important for "creating impact". By contrast, a temporary slowdown in boosting absorptive capacity within a country or a region is likely to have a significant impact on that capacity in the long term. We discuss these features of absorptive capacity in more detail in the following section (1.3).

The positive contribution of both basic and applied knowledge to GDP results from knowledge utilisation and not only from knowledge generation. It is very important, then, for that knowledge to be used not only by those who generate it but also by other institutions, enterprises and people, in short to be "open". Only when knowledge is utilised more widely as a genuine public good, and not only by its inventor or the enterprise for which the inventor works, can its potential be exploited to the full. Many of the knowledge flows that have arisen in this manner are naturally transnational in nature, certainly in the context of globalization and open innovation processes.

In turn the usefulness of knowledge depends on its quality. Impact of scientific publications and patents is measured with indicators based on citations. High impact publications are highly used publications. Empirical studies based on such measures show that excellent researchers or academic institutions tend to cooperate more with private companies. High duality in research should thus be promoted not only for academic purposes but also because it is fundamental to the performance of open innovation processes. It is in this sense that the new emphasis on the 3 O's takes on its full meaning. It brings to the forefront one of the main, still by and large unexploited, "potential" growth impact of Europe's research and innovation system: the opening up, enhancing European as well global and local externalities of knowledge investments. Excellence is the engine which powers open knowledge through the system once the channels have been cleared.

This process of "open" knowledge-sharing assumes correctly that most innovations will be the result of collective processes. It is possible for a specific technological invention that forms the basis for an innovation to be ascribed to a single inventor or a "national" team of inventors, often in the employ of an enterprise or one university. But even in those, rather exceptional cases, those inventors in turn will have made use of knowledge generated in other enterprises, universities and knowledge institutions, including foreign ones. Without existing knowledge being inputted into the invention process, corporate R&D would not be productive. In this respect, an innovation system is by definition "open": consisting of 'the network of institutions, rules and procedures that influence the way by which a country acquires, creates, disseminates and uses knowledge. (Chen & Dahlman, 2004).

1.2.5. CONCLUSIONS

Commissioner Moedas, in his "New Start for Europe" speech[5] launching the 3 O's notion, stated: "Open innovation is about involving far more actors in the innovation process, from researchers to entrepreneurs, to users, to governments and civil society. We need open innovation to capitalise on the results of European research and innovation. This means creating the right ecosystems, increasing investment, and bringing more companies and regions into the knowledge economy".

Starting with the discussion on "national system of innovation", the recognition that R&D policies alone will not facilitate the diffusion and assimilation of knowledge in an open economy, implies that complementarities and synergies between a large set of very different policy fields will be essential for reaping the full benefits from the 3 O's.

As we argued here in this first section, this "open" policy framework going well beyond traditional support for R&D, should enable European countries to better utilise and absorb knowledge generated within their own borders or elsewhere in Europe and the world. And in this "open" knowledge world, in order to absorb knowledge, knowledge institutions themselves: from universities, public research organisations and private research labs to individual researchers, entrepreneurs and government officials will have to keep pace with the highest quality levels of international knowledge generation.

[5)] *Brussels, 22 June 2015.*

We have also seen that there are limitations of the economic growth models currently in use. They do not fully measure the impact of openness in GDP and do not embrace the new and broader innovation dynamics where new actors and areas participate in the value creation. Finally, the growth models do not allow for any innovation policy learning; they do not measure the additional effect of open policy approaches and instruments. This calls for the elaboration of a widely recognised Knowledge function connected to and compatible with revised macroeconomic growth models. Such a knowledge function would allow policy makers and innovation actors measure the marginal impact of a revised knowledge-innovation nexus through experimentation, learning and adaptations.

1.3 OPEN INNOVATION, THE DIFFUSION OF KNOWLEDGE AND PRODUCTIVITY GROWTH

Luke Georghiou and Frédérique Sachwald

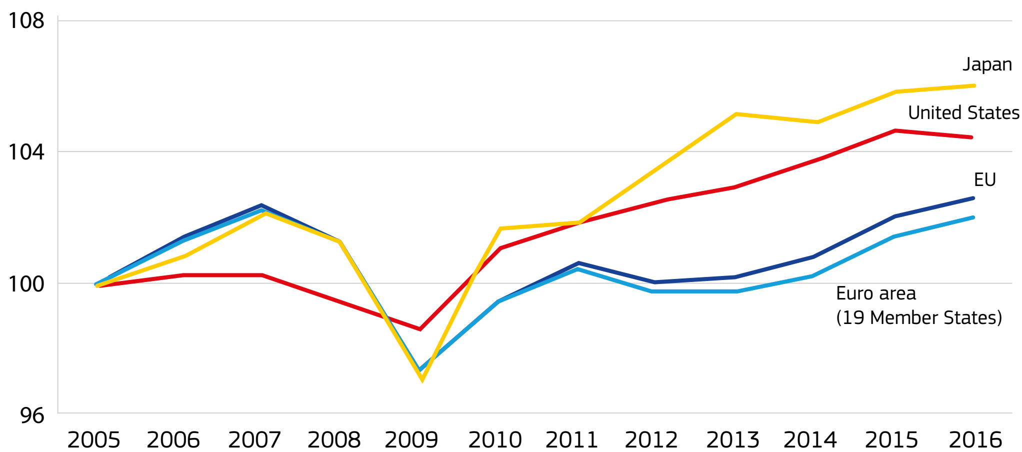
1.3.1 INTRODUCTION

As we saw in the previous macro-economic section, the openness paradigm underlying the 3 O's has at its core the increased flow of knowledge between organisations, including between academic institutions and firms and between different types of firms. Knowledge in this case may be embodied in capital artefacts or disembodied, flowing through formal or informal communication and including knowhow.

At the micro-economic level, openness should facilitate the 'trickle-down' of productivity across firms the diffusion of innovation improving firm performance and productivity in Europe. This section explores this issue and suggests policy directions to reinforce convergence towards increased productivity levels.

Since the early 2000s, productivity has been growing more slowly in the Euro area than in the United States (European Commission, 2016a). Furthermore, total factor productivity has failed to recover from its pre-crisis levels in the EU (European Commission, 2016b).

Figure I.1: Evolution of Total Factor Productivity, 2005-2016. Index 2005 = 100



Source: DG Research and Innovation – Unit for the Analysis and Monitoring of National Research and Innovation Policies. *Data:* DG ECFIN

For about half of Member States this is the result of an actual decline in multifactor productivity in the most recent period. The cause of the transatlantic gap was identified by Van Ark et al. (2008) to be pre-crisis and to be the clear consequence of the slower emergence of the knowledge economy in Europe compared to the United States. The authors cite the high level of investment in information and communications technologies (ICT) in the US as driving rapid productivity growth in the market services sector of the economy in contrast to the situation in Europe. Faggio et al. (2010) found that the change in ICT capital intensity in a firm is the principal explanatory factor for within industry variations in productivity.

In any sector, productivity is a spectrum across the constituent firms. As Syverson (2011) notes in a comprehensive review, "*plant at the 90th percentile of the productivity distribution makes almost twice as much output with the same measured inputs as the 10th percentile plant*". A recent contribution of OECD (2015) has showed that over the 2000s labour productivity for manufacturing firms at the global frontier[6] increased at an average annual rate of 3½ per cent, compared to an average growth in labour productivity of just ½ per cent for non-frontier firms. This productivity gap is even more pronounced in the services sector. Numerous explanations have been offered to explain differences between firms within and across countries. Factors within the firm include managerial talent, quality of labour and capital, the level of IT and R&D, learning by doing, product innovation and firm structure. Other explanatory factors relate to the external environment including productivity spillovers, competition, regulation and input markets. In their review of productivity heterogeneity between firms, Dosi et al (2010) pointed to three categories of explanatory factors: quality of inputs, R&D and innovation strategies, and idiosyncratic organizational capabilities.

Since our principal interests relate to the contribution of research and innovation, it is necessary to establish first the contribution that these make to productivity. Syverson (2011) points out that while there is an extensive literature linking R&D to productivity, establishing the direction of causation is more difficult. Hall (2011) indicates that there is "an economically significant impact of product innovation on revenue productivity and a somewhat more ambiguous impact of process innovation" – this because output can be increased while revenue is unchanged. A comparison in four European countries found that: "Process innovation is only associated with higher productivity in France, in the other countries there is no such connection. Product innovation is associated with higher productivity in France, Spain and the UK, but not in Germany" (Griffith et al, 2006). Furthermore, there needs to be made a distinction between incremental improvement (for example progressive automation of manufacturing processes) and disruptive change where new technologies or services and often new entrants displace incumbents (for example internet retailing).

In both of the above cases Dosi et al (2010) suggest that there is an inherent asymmetry likely to emerge in a sector, with innovation capabilities often concentrated in a small number of firms and the diffusion of process innovation also driving differences both because of the time taken to diffuse and because of variation in the capacity to adopt. The latter is related to the degree of firms' "absorptive capacities" (see also analysis in section 1.2 and 1.4). This notion has been developed to underscore the dual role R&D investment plays in a firm: it serves both to generate new knowledge and to increase the capacity of the firm to identify and use new external knowledge (Cohen and Levinthal 1989). Absorptive capacity has an important role to play in open innovation processes and in the diffusion of innovation between firms and throughout the economy, as suggested by the representation of an innovation system below (Figure I.2). In turn, absorptive capacity depends on the quality of the knowledge to which firms have access and on the quality of the available human resources. As a consequence, the characteristics of education, higher education and training policies should be adapted to the needs of innovation and/or diffusion depending on the specific situation of the country. This is an important mission for European universities and other higher education institutions.

More generally, absorptive capacity helps understanding the need to align a country's ambitions in terms of knowledge generation, innovation and innovation diffusion. IT innovation and its diffusion within different economies can be taken as an illustration of the importance of this qualitative alignment.

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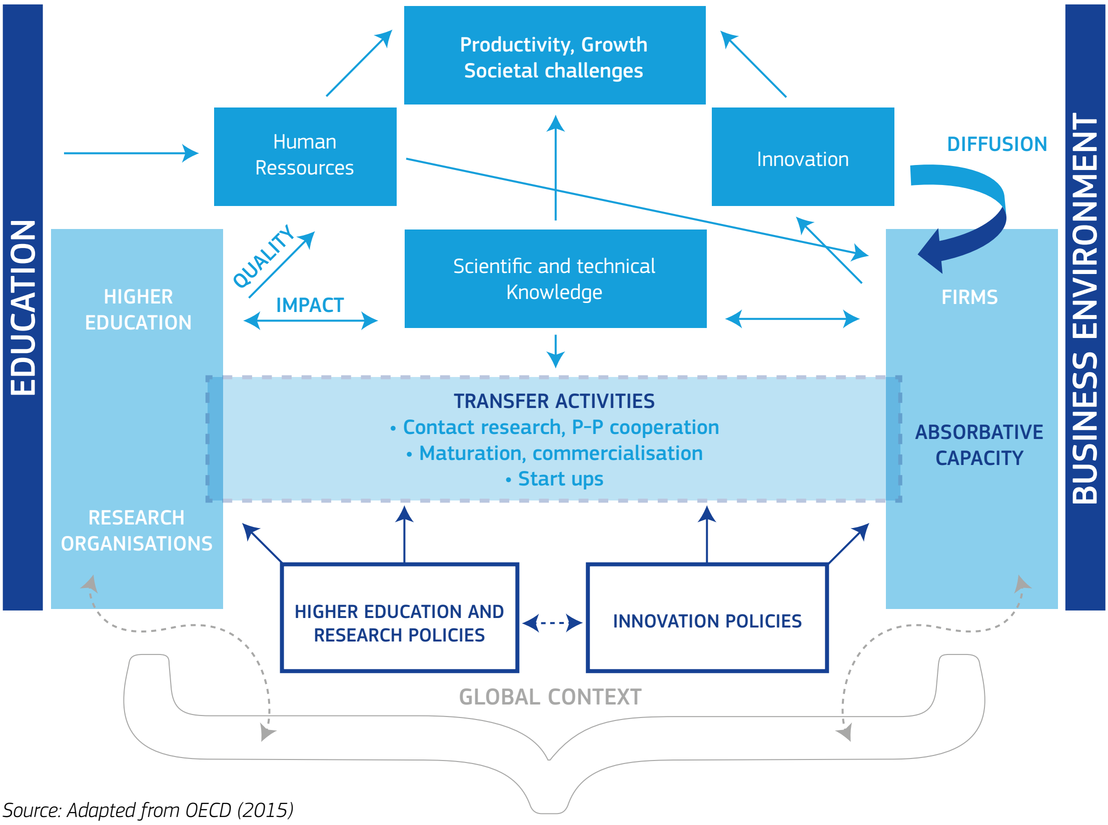
[6] In each sector, the 100 firms with the highest productivity at world level, whatever their country.

Figure I.2: Impact of the quality of knowledge and education on innovation and its diffusion between firms



Source: Adapted from OECD (2015)

1.3.2 INNOVATION AT THE FRONTIER AND THE POTENTIAL FOR 'TRICKLE-DOWN' OF PRODUCTIVITY GROWTH

The rising gap in productivity growth between the global frontier and other firms raises questions about: *i*) the quality of R&D results as a source of innovation and competitive advantage for global frontier firms; *ii*) the ability of the most advanced firms nationally to adopt new technologies and knowledge developed at the global frontier; and *iii*) the diffusion of existing technologies and knowledge from national frontier firms to laggards (OECD, 2015). These three types of questions have to be addressed with adapted policies. Indeed, innovation at the frontier requires different resources from those necessary for diffusion. In turn, diffusion will take place in different national contexts, where institutions and resources will require more or less adaptation. In other words, the countries that have firms at the global frontier can increase the density of this population of firms, while the issue of diffusion and productivity trickle down should be considered within each country's specific context.

Depending on the local context, policies will have to focus on the development of resources for innovation and/or for diffusion, as illustrated by Figure 1.2. What follows focuses on the issue of diffusion of new knowledge and technologies. The spectrum of inter-firm relations can range from the arms-length effects of competition, through the acquisition of productivity inducing innovations, or demand for innovation exerted through supply chain linkages, and improvement through broader but purposive flows of knowledge in an innovation ecosystem. In the following sections we explore three major mechanisms of diffusion.

1.3.2.1 COMPETITIVE PRESSURE ON NATIONAL AND EUROPEAN MARKETS

While there is a spectrum in the intensity of competition, the core question to raise in the European context is whether market imperfections create 'safe spaces' for less productive firms (see also section 4 in Chapter 4 on pro-innovation regulation). These could be indirectly protected product markets but could also include labour markets, which depress the price of labour and hence reduce the incentive to become more productive. Access to these markets by more productive entrants could potentially induce incumbents to respond by becoming more productive themselves, and ultimately reaching the point where they no longer needed the shelter of their particular niche or national conditions. Aghion et al. (2009) found a divided situation. Foreign (more productive) firm entry in technologically advanced sectors had a positive influence on innovation and productivity growth, while entry by such firms reduced innovation and productivity growth by domestic firms in lagging sectors, because such firms are discouraged by the cost of catching up. Haskel et al. (2007) similarly concluded that there are productivity spillovers from inward FDI to domestic plants estimating that a 10-percentage-point increase in foreign presence in a U.K. industry raises the total factor productivity of that industry's domestic plants by about 0.5%.

From a policy perspective, these results suggest the need to address failures in product markets resulting from regulatory, cultural or other barriers to innovation which may be reducing the incentives for the incumbents to innovate (see also Chapter 4).

1.3.2.2 INNOVATION ECOSYSTEMS AND PROCUREMENT

Procurement is indicated as a strong influence both in general innovation surveys and in specific studies of (public) procurement. A survey of 800 suppliers to the UK government found that the lack of demand from the market is the single most important obstacle for innovation (Georghiou, et al., 2014). The study was the first to establish on a large scale that public procurement leads to innovation. The authors reported that: "Out of the 94% innovative organisations in the responding sample, 67% indicate that bidding for or delivering contracts to public sector clients has had some impact on their innovation activity: 25% of the innovating organisations claim that all of their innovations have been the result of public procurement".

Furthermore over half of the sample had won a public sector contract in the last three years because of innovation and increased their R&D expenses as a result of delivering or bidding for public sector contracts. Given the interest here in private buyers, it is interesting to note that for this group at least, public buyers were a more important source of innovation than private buyers. Nonetheless as a consequence of the public-buyer induced innovation, more than half increased sales in the private sector and a smaller share of 29% report increased or enabled overseas sales.

Less-studied but of similar clear relevance are company ecosystems, in which a prime systems assembler can exert pressure down the supply chain to be more innovative and hence contribute to productivity. Sectors with the strongest supply chain structures such as aerospace and automotive may of necessity be highly prescriptive with their suppliers. This can be seen as a purposive extension of productivity. Spillovers in the supply chain have been examined by Isakssona et al. (2016) who found that: "buyer innovation has a positive and significant impact on supplier innovation. We find that the duration of the buyer–supplier relationship positively moderates this effect, but that the technological proximity between the two firms does not have a significant effect on spillovers." Ikeuchi et al. (2015) examined R&D spillovers that result from buyer and supplier relationships at the transaction level using a dataset of over 20,000 Japanese manufacturing plants. They found that R&D stocks of buyers and suppliers provide a substantial productivity performance premium over and above the effect of technologically and geographically proximate R&D stocks.

It may even be the case that procurement arrangements inhibit innovation in certain circumstances because of what Frankel (1955) called 'technological inter-relatedness'. In faster-moving sectors they may set more general parameters but be open to innovative improvements. Mechanisms which allow sectors to move forward more easily include collective foresight and road-mapping exercises which reduce the risks for firms of innovating in directions which may leave them isolated from key customers. Research and innovation partnerships designed to amplify channels of influence could be one implication. Early findings from current research on innovation ecosystems in Europe indicate that firms aim to exert influence in the network of alliances in which they operate through the quality of products and services and by developing new technology which offers something to their partners[7]. In consequence flows of knowledge were identified as the predominant form of interaction.

1.3.2.3 ADVISORY SERVICES FOR THE DIFFUSION OF TECHNOLOGY AND INNOVATION

Diffusion of innovation is of course a well-studied phenomenon. It may be inhibited by either the regulatory system per se or by fragmentation and local variation preventing the development of a single market for innovative products and processes. Barriers to diffusion between sectors, between countries or regions are all of potential interest.

In most countries, public and private institutions have been designed to help diffusion of innovation, ranging from technological centres to policies stimulating interactions between firms. These schemes may be numerous and represent substantial public funding, but their efficiency is often not well understood and questions may be raised about their orientation, for example they may be too concentrated in traditional sectors and they may reinforce 'lock-in' to those sectors rather than encouraging firms to migrate to new opportunities open up by innovation. They may also insufficiently promote the connection to global open innovation networks as part of the diffusion process (Sachwald, 2013). In a review of evaluation evidence on the efficacy of technology and innovation advisory services (one of the main instruments to promote diffusion), Shapira and Youtie (2016) found that benefits to participating firms included higher productivity, and new product development and innovation. However, the advisory services were normally relatively modest and only rarely were they resourced to achieve 'significant and fundamental improvements'.

[7] *Industrial innovation – managing the ecosystem, Presentation of Horizon 2020 project Industrial Innovation in Transition (IIT) at ESOF2016, Manchester 24 to 27 July 2016 http://www.esof.eu/the-programme/full-programme/presentation-library.html?file=files/_pdf/ESOF%202016%20Session%20Presentations/Industrialinnovation-managingtheecosystem.pdf*

1.3.3 CONCLUSIONS

To a certain extent this review on the potential of productivity gains through a more open policy framework reinforces some existing policy directions, notably the drive towards the digital single market and within that in particular the strand promoting the digitization of European industry and its five key priority areas 5G, cloud computing, internet of things, data technologies and cyber security. However, these measures do not in themselves address the productivity gradient and indeed could result in it being reproduced in new sectors if the policies do not reach deep levels of diffusion. Of the explanations we have considered it would appear that competitive pressure is a positive driver and that efforts to open markets, establish pan-European standards and regulation should continue but are not a sufficient condition. An even stronger driver is the connection to global markets which will drive European firms to match state of the art levels of competitiveness. The safe spaces referred to above may go hand-in-hand with both geographical and cultural marginalisation.

A second conclusion is also the need for distinguishing policies that target the needs for innovation from those of diffusion. Accordingly, different policies have to target different types of firms. In particular, action is needed to encourage lagging firms to engage in the necessary process of catching up. This involves enhancement of their innovation and absorptive capabilities. R&D support does of course work in this direction but the lack of absorptive capacity to take-on, adapt and implement new technologies is related to complementary assets and adequate training of human resources. Policies more directly targeting enhancement of firms' capabilities would increase such capacity. Of particular relevance are those measures which seek to support enhancement of the workforce by supporting recruitment of R&D personnel and more generally ensuring that the work force is adequately trained, both through education and through professional training. In turn, this implies that education and higher education are adapted to the needs of the country or region and of sufficient quality. Increased interactions between public and private institutions will be more productive in terms of innovation if public research generates high impact research. A number of relevant policies are built around the idea of a partnership with a scientific institution whereby the project is a placement for a masters or doctoral candidate. This gives the additional benefit of creating a strong open innovation channel linking to the parent scientific institution. While such policies exist sporadically on a national basis, there is potential for a European level equivalent to drive cross-border mobility and give the added benefit of international experience.

Thirdly, the area of procurement and supply chain has untapped potential. Policy measures to harness public procurement in support of innovation (for example initiatives such as the Lead Market Initiative and those for pre-commercial procurement of R&D (PCP)) are now reasonably well-established though requiring scale-up. Recent evidence[8] has shown that for a relatively small investment PCP schemes have opened a route to the market for new players, with 71 % of contracts won by SMEs (SME lead bidder, bidding alone or with partners) compared to 29 % average in public procurements across Europe. What is currently lacking are measures to incentivise private procurers, normally those at the top of a supply chain, to be more demanding but open to innovative solutions. Two common barriers here are the failure of purchasers to be aware of alternative options and an aversion to the additional risk of procuring innovative solutions (Uyarra et al., 2014). The first of these can be addressed through innovation platforms designed to bring suppliers and users together and engage them in joint horizon-scanning activities. This was part of the initial thinking behind the societal challenge approach, and could be addressed by means of an 'insurance' approach, whereby public funding is used to offset the costs of having to revert to an off-the-shelf solution if the intended supplier innovation does not materialise. This policy instrument could be an important adjunct for the European Innovation Council (see section 3 in Chapter 4) as it would provide a first track to the critical first market application for innovative companies receiving R&D support.

Finally considering the increasing importance of industrial innovation ecosystems, efforts could be made to align initiatives around these by favouring collaborative programmes that include in their scope not only specific project objectives but wider arrangements to enhance the flows of knowledge and people.

There are several policy instruments which exist to drive enhanced diffusion of technology. These measures are set out in Figure I.3 which distinguishes between those encouraging experimentation with new knowledge and technologies and those promoting the diffusion of existing knowledge an technologies. In reality, the conceptual distinction is often blurred at the level of the individual firm as the acquisition of a new knowledge or technology may often itself stimulate further innovation in the user base. This may happen through feedback to the supplier, adaptation or through organisational innovation to accommodate and exploit the technological opportunity.

[8] See https://ec.europa.eu/digital-single-market/en/news/updated-results-pre-commercial-procurements-pcp-projects

Figure I.3: Policy instruments for promoting innovation and innovation diffusion, by type of firms

				RELEVANCE TO THE PERFORMANCE OF FIRMS, BY TYPE		
Key dynamics to be promoted	Relevant policies	Channels	Outcomes	Global productivity frontier firms - GF	National productivity frontier firms - NF	Laggard firms
Experimentation with new knowledge and technologies	Research and innovation policies (R&D, fiscal incentives for R&D, IPR, etc.	Promoting an efficient balance between basic and applied research	Pushing the global frontier via radical innovation and knowledge absorption from the science base	0 0	0	
	International coordination of innovation policies	Compensating firms for market failures in the provision of innovative efforts		0 0	0	
	Framework policies (product market regulations, bankruptcy & judicial efficiency, financing, openness)	Competitive pressures, creative destruction	More experimentation. Innovative entrants and pressures on incumbents to innovate	0 0	0	
			Enhanced market size raise returns to innovation	0	0	
		Efficient resource allocation (capital, labour, skills)	Entry into global markets enables interactions with GF	0	0 0	
			Lower skill mismatch increases the pool of skills to innovate	0	0 0	

Diffusion of existing knowledge and techno-logies	Framework policies, especially product market regulations	Competitive pressures	Greater market discipline incentivises innovation adoption		0 0	0 0
	Basic research	Compensating firms for mar-ket failures in the provision of innovative efforts	Complementary knowledge based assets facilitate adoption		0 0	0
	R&D fiscal incentives		Knowledge externalities from academic research lead to more innovation		0 0	0
	R&D collaborations between firms and universities	Knowledge transfer and spillovers	New entrants can experiment at small scale and access research facilities		0	0 0

Source: Adapted from OECD (2015).

1.4 THE DIFFUSION DEFICIT AND ECONOMIC CONVERGENCE

Andrés Rodríguez-Pose, Ron Boschma, Lena Tsipouri, Andrea Bonaccorsi

1.4.1 INTRODUCTION: AGGLOMERATION TRENDS AND POLARISATION

While cross-country disparities have tended to diminish in the European Union (EU) as a result of European integration, within country disparities have increased and, in some cases, very rapidly (Puga, 2002; Cuadrado-Roura et al., 2016). Economic activity and innovation have become more concentrated in core cities and regions, while many former intermediate and less developed regions have lagged behind. This situation has worsened since the outbreak of the 2008 economic crisis (Crescenzi et al., 2016; Cuadrado-Roura et al, 2016). Large cities, such as Amsterdam, Bucharest, Copenhagen, Helsinki, Lisbon, London, Madrid, Paris, Stockholm, or Warsaw, are generally emerging out of the crisis in a better shape than many of their hinterlands. This increasing polarisation in both economic activity and innovation is affecting the overall growth prospects not only of the regions lagging behind, but of the EU as a whole (Ezcurra, 2009).

In open innovation systems, innovation has a tendency to concentrate spatially (Simmie, 2005; Naz et al. 2015). The EU is no exception. R&D and the main factors driving innovation have become progressively heavily concentrated in the European landscape as European integration has taken hold (Navarro et al., 2009), leaving a persistent gap between central and peripheral regions in the EU in terms of innovation capacity. This unequal pattern is quite stable over time (Capello and Lenzi, 2015).

Knowledge spilling over from innovative activities is often limited. Firms investing in R&D try to appropriate the returns from innovation, meaning that the diffusion of knowledge is geographically bounded. As has been demonstrated in the case of Europe, spillover effects suffer from a strong distance decay effect and are rarely felt beyond 250 km from their knowledge source (Moreno et al., 2005; Rodríguez-Pose and Crescenzi, 2008). This is especially true for tacit knowledge which does not travel easily over large geographical distances (Gertler, 2003; Storper and Venables, 2004).

Consequently, regions with a high concentration of firms investing in (private) R&D and with stronger labour pools and opportunities for face-to-face encounters not only innovative more, but also perform better economically (e.g. Anselin et al., 2000; Capello and Lenzi, 2015).

This also implies that innovation is not simply the result of increasing R&D investment everywhere in the EU. The conversion of R&D into innovation is far from automatic and heavily depends on local conditions. It is not necessarily the case that places of knowledge creation and places of innovation overlap. Many European firms, regions and countries have problems in absorbing and exploiting new knowledge from an economic point of view and are not particularly able to turn knowledge generation into innovation. This is especially true in the more peripheral regions in the EU where R&D is often spatially fragmented, concerns mainly public, not private R&D, and is concentrated disproportionally in scientific disciplines like Social Sciences and Humanities (Rodríguez-Pose, 2015). Low quality of training and poor institutional conditions are additional barriers for innovation. Hence, in a more open and integrated system of innovation, simply investing more in R&D in lagging regions is unlikely to yield the expected high impact research, innovations and economic benefits.

In other words, the linear model of R&D to innovation needs to be reconsidered. Scholars have identified a number of conditioning factors that shape and mediate the relationship between R&D and regional economic development: (1) the absorptive capacity of local firms; (2) the presence of 'related variety' in regions which enhances local knowledge spillovers and diversification (Frenken et al. 2007; Boschma and Iammarino 2009); and (3) a right set of formal and informal institutions, as embodied in high quality of government (Rodriguez-Pose and Di Cataldo, 2014) and bridging social capital (Cortinovis et al. 2017); (4) agents of change better supporting private R&D; (5) building on "pockets of excellence"; and (6) dealing with global value chains and digitalisation. We discuss each of these conditioning factors one by one below.

1.4.2. DIFFUSION OF INNOVATION WITHIN COUNTRIES

1.4.2.1. ABSORPTIVE CAPACITY

Firms can benefit from co-presence and co-location, as geographical proximity enhances knowledge spillovers. However, investing more in R&D in regions will not necessarily create knowledge spillovers: co-location of firms per se is not a sufficient condition for knowledge diffusion and absorption to take place. Knowledge will not spill over between local firms when they lack absorptive capacity as we argued before under sections 1.2 and 1.3. Due to the tacit nature of knowledge, firms generally only understand, absorb and implement external knowledge that is close to their own knowledge base (Cohen and Levinthal, 1990). Therefore, effective knowledge transfer requires broadening the absorptive capacity of firms (Giuliani and Bell 2005). Increasing the level of R&D and human capital in regions represents one approach to addressing this issue. However, more R&D and human capital will only be translated into innovation when they are of sufficient quality and are geared toward the specific demands of local firms. This is especially relevant for peripheral regions, endowed with many small enterprises with a low absorptive capacity, and where there often is a poor match between the local supply of research and education on the one hand, and local demand for knowledge and workers on the other hand (Rodríguez-Pose and Vilalta-Bufí, 2005).

Being exposed to extra-regional knowledge is also considered crucial for regional development because inter-regional networks can bring in new knowledge and variety into the region (Asheim and Isaksen, 2002; Bathelt et al., 2004). However, non-local relations as such are on their own not sufficient to guarantee effective knowledge transfer between local and non-local agents. Again, transforming knowledge into innovation depends on the absorptive capacity of local firms and institutions. There is a rapidly growing body of literature that focuses on innovative firms in peripheral regions that cannot draw on local resources and, therefore, rely on non-local linkages instead (Fitjar and Rodríguez-Pose, 2011; Isaksen and Karlsen, 2012; Grillitsch and Nilsson, 2015; Isaksen, 2015; Shearmur, 2015). These firms show strong firm-internal capabilities which turns out to be a prerequisite to build crucial non-local linkages.

1.4.2.2. RELATED VARIETY IN REGIONS

Another potential barrier to local knowledge spillovers is the lack of cognitive proximity between local firms and sectors (Nooteboom, 2000). Many industries cannot meaningfully interact and generate innovation in more open economies because they do not share similar knowledge, skills and other capabilities. Knowledge will only be exchanged effectively when the cognitive distance between sectors in a region is not too large: local sectors need to be related, or cognitively close (Frenken et al., 2007). Related variety provides opportunities for regions to induce a learning process across sectors and to make new inter-industry combinations that lead to more innovation, greater productivity, and higher regional growth. Empirical studies have demonstrated that related variety increases regional employment growth (Essletzbichler, 2007; Frenken et al., 2007; Boschma and Iammarino, 2009), especially in knowledge-intensive industries (Hartog et al., 2012). Cortinovis and Van Oort, (2015) have proven that related variety is associated with higher employment growth and lower unemployment growth in the most knowledge-intensive regions in Europe.

In particular, related variety provides opportunities to make new combinations that give birth to new activities. Frenken and Boschma (2007) depicted local industry formation as a branching process in which the local presence of industries that are related to a new industry increases the probability for a new industry to occur. Related industries act as a major source of potential successful entrepreneurs (Klepper, 2007), relevant knowledge, and skilled workers (Boschma et al., 2009). This is why, for example, the British car industry concentrated in the Coventry-Birmingham region, and not elsewhere in the UK. The area was the main location of related industries like cycle and coach-making industry out of which the new car industry branched (Boschma and Wenting, 2007). And the more related the variety of industries vis-à-vis the new industry, the more likely a region is successful in that new industry.

There is growing evidence that regions tend to diversify into new activities that are related to existing local activities. Hausmann and Klinger (2007) demonstrated that countries tend to develop new export products that are related with existing export products, and that countries with many related export products have more options to diversify into new export products. Neffke et al. (2011) systematically investigated the diversification of regions in industries that are new to a region. They found that an industry had a higher probability of successful development when technologically related to pre-existing industries in the area. Rigby (2015), when looking at the technological diversification of regions using patent data, found that technologies related to pre-existing technologies in US metropolitan regions had a higher probability to enter that region. These findings on related diversification have been replicated in many studies (Boschma 2017), also for new eco-technologies (Tanner, 2014; van den Berge and Weterings, 2014).

Recently, studies on diversification have been carried out for European countries and regions. Boschma and Capone (2016) showed that countries in Eastern Europe tend to diversify in new industries that are very closely related to their existing industries, while in Western Europe, this tends to be less the case. Cortinovis et al. (2017) conducted the first study comparing diversification of regions in EU countries. The study confirmed the results of previous single-country studies: regions are more likely to develop new specializations in industries that are strongly related to already existing industries in the region. Evidence shows that European regions also diversify into related technologies, and regions are more likely to experience growth in technological activities when related to their specific knowledge bases. Moreover, regions find it difficult to specialize in more complex technologies, but once they succeed, they are more likely to experience higher technological growth. (See figure I.4)

Figure I.4: Policy framework to assess industries

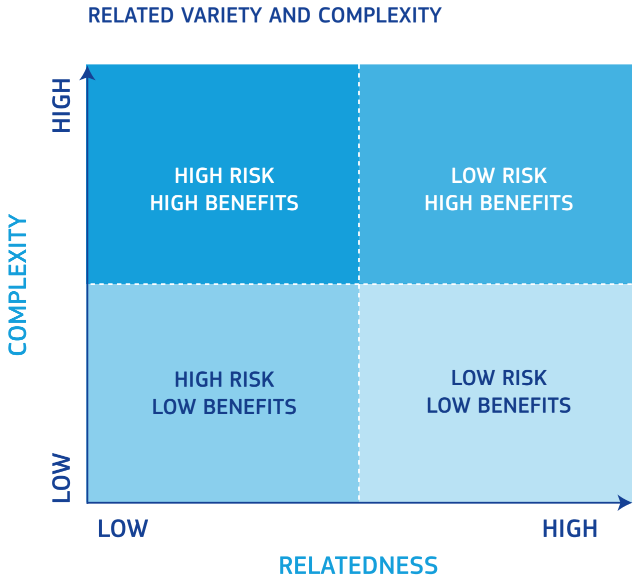
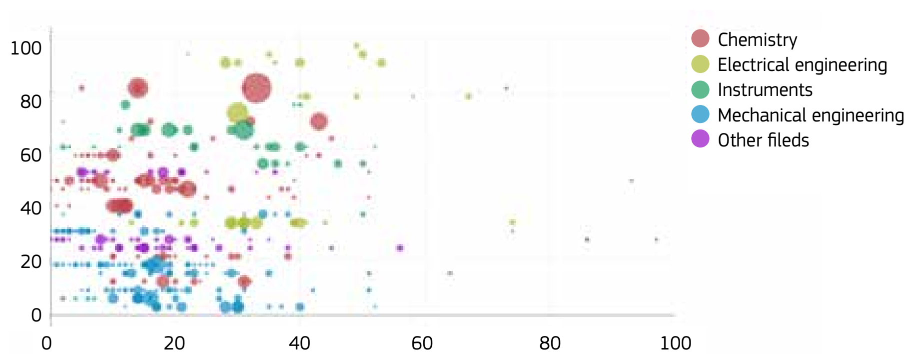


Figure I.4 illustrates different policy choices based on related variety and complexity, following Balland et al. (2017). Ideally, for the development of new growth paths in the region, policy makers would like to have many choices in the top-right corner, and few options in the bottom-left corner. This would increase the competitiveness and economic sustainability of the regions at relatively low risk. The top-left and the bottom-right cases are more ambiguous and require a political choice: which is the amount of risk considered as acceptable compared to the expected benefits when diversifying.

Figure I.5: Île de France (France)



Figures I.5-8 applies this framework to four NUTS2 regions in Europe. It shows the potential choices for four different types of regions: a Central region (Île-de-France, FR10, France), a High-tech region (Noord-Brabant, NL41, Netherlands), an Old industrial region (Lancashire, UKD4, United Kingdom), and a Peripheral region (Extremadura, ES43, Spain). The figures make clear that not all regions are in the same situation to build new growth trajectories.

Île-de-France is a big agglomeration, where many activities exist. Therefore, it has a large set of capabilities it can rely on to branch towards new activities. In fact, it has a relatively high relatedness with many other technological domains. Thus, this offers to the region numerous low-risk paths to diversify; some of them are complex technologies.

The case for Noord-Brabant is different. This is a smaller region but already very innovative, particularly in electrical and electronics domains. As a consequence, compared to Île-de-France, it has a shorter menu of low-risk paths. However, most of these low-risk paths are towards complex technologies.

Figure I.6: Noord Brabant (Netherlands)

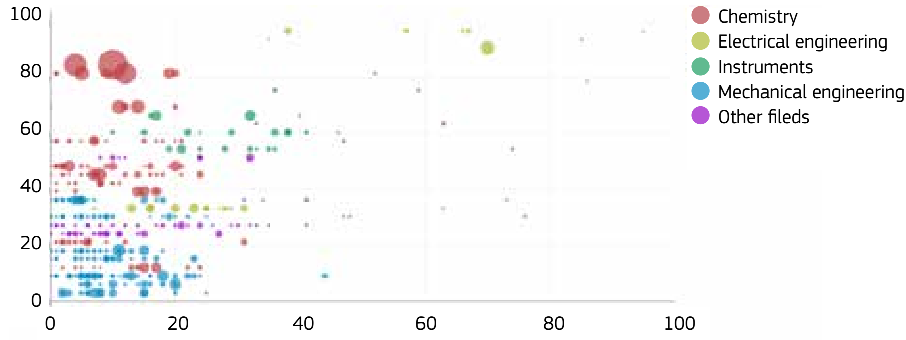


Figure I.7 shows the case of Lancashire, an old industrial region in the Northwest of England. For Lancashire, there are also several domains with relatively high relatedness. However, from the complexity angle the situation is quite different. In fact, Lancashire capabilities are mostly related to low complex domains built around mechanical engineering. Activities in chemistry or electrical domains, with high complexity and high growth potential, are quite distant from the set of existing capabilities in Lancashire.

Figure I.7: Lancashire (United Kingdom)

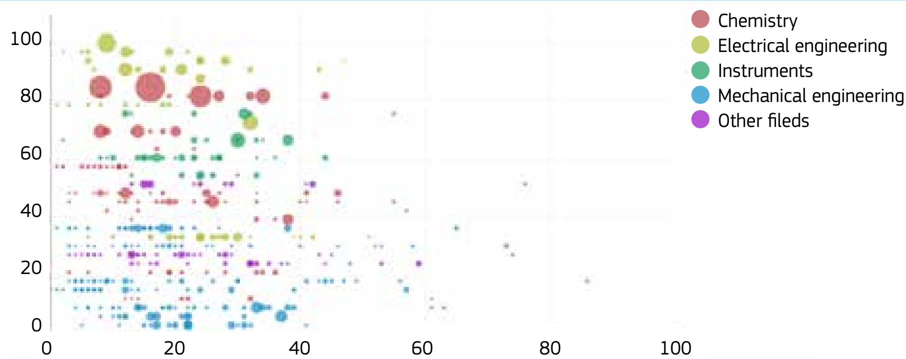
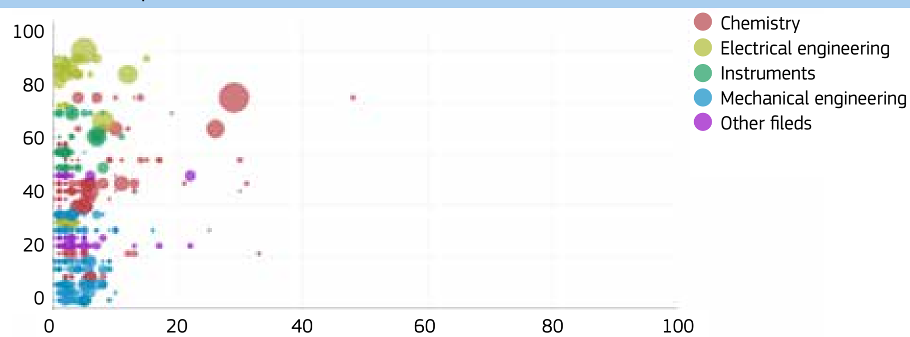


Figure I.8: Extremadura (Spain)



Finally, figure I.8 shows the case of Extremadura, a peripheral region in the Southwest of Spain. In this case, the set of options for regional diversification is quite restricted. Most of the potential technological domains show low relatedness with the existing set of capabilities in Extremadura. Although some chemical activities have a bit stronger relatedness, this is still lower than for the other regions, and the list of option is scarce. In Extremadura, the low relatedness applies to both, complex and non-complex technological domains. (Analysis by J. Crespo et al. 2017) *Source: J. Crespo, based on OECD-RegPat Database*

Despite all the evidence that relatedness is driving related diversification, one could ask the question of which are conditions that enable more radical structural change and provide the basis for the development of new growth paths. Although systematic evidence is still lacking, preliminary research underlines that in order to create new growth paths, regions will have to rely on agents and resources that come from other regions. Studies have documented the importance of migrants for the development of new specializations in regions (Bahar and Rapoport, 2014). Transnational entrepreneurs, like successful return migrants (Saxenian, 2006), have played a crucial role in early industry formation in certain places (Drori et al., 2009; Sonderegger and Taube, 2010), but only when they become anchored in their regional context (Vale and Carvalho, 2013; Binz et al., 2016). Neffke et al., (2015) found that the creation of new subsidiaries established by large firms located elsewhere induces structural change in regions, because the ownership link subsidiaries have with their parent company in their home region allows them to develop activities that rely on resources that do not exist in the host region and, so, can overcome the liability of newness. This is in line with work on MNE's that shift specializations of regions in new directions (Crescenzi et al., 2015). And policy-driven change (through e.g. fundamental research and public procurement) can induce local radical transformations, Silicon Valley being a classical case (Mazzucato, 2013).

1.4.2.3. INSTITUTIONS AND GOOD GOVERNANCE

In open innovation systems, the capacity to generate innovation is more dependent than previously thought on local conditions. Many research centres and firms fail to make the bond from knowledge generation to innovation, because of the presence of inadequate or outright innovation-averse sets of institutions. Institutions are crucial for innovation and regional growth because they regulate and coordinate actions of agents. Hence, being an innovative region is not just a matter of having access to local or non-local knowledge, absorptive capacity and related variety, but also whether the institutional context facilitates and promotes efficient scientific production, interaction and knowledge sharing between agents and sectors. Organizations need to connect and interact to get access to knowledge, capital and labour, but frequently poor institutions act as a powerful barrier limiting interaction and knowledge sharing.

Although it has for long been known that institutions are the outcome of a long history and differ widely between countries (e.g. Hall and Soskice, 2001), lack of adequate subnational data has until recently prevented a more accurate assessment of the role they play in shaping innovation outcomes (Rodríguez-Pose, 2013). Work by Charron et al., (2013) has mapped quality of government across regions of Europe, signalling that institutional quality varies enormously across European regions. This variety in institutional quality makes some regions much more capable of turning research into useful knowledge and knowledge into innovation and economic development, while other regions have such weak institutions that R&D is unlikely to lead to higher economic development (Rodríguez-Pose and Di Cataldo, 2014).

The quality of local institutions has an impact on the economic returns of R&D investment. Rodríguez-Pose and Di Cataldo (2014) show that lagging European regions lack a socio-institutional infrastructure needed to obtain high returns from R&D. Low policy-making capacity, high levels of corruption, poor accountability, insider-outside problems, rent-seeking and elite capture, and limited financial resources represent strong structural barriers that limit the capacity of research and innovation policies to take hold. Improving local institutions needs therefore to become an integral part of research and innovation policies as, for most lagging regions of Europe, improvements in innovation may result to a greater extent from improving local government quality and governance than from devoting additional resources to R&D and higher education.

Cortinovis et al. (2017) investigated the effect of regional institutions on the ability of European regions to diversify. They found a positive effect of 'bridging social capital' (cross-group interaction) in a region, while 'bonding social capital' (intra-group interaction) had no or even a negative effect on regional diversification. This suggests that inclusive social capital that can bridge different social groups in society enables new combinations between different economic activities needed for a successful diversification process. In regions with a low quality of government, bridging social capital had an even stronger positive effect on regional diversification, while bonding social capital had a stronger negative effect. So, bridging social capital in regions seems to be a crucial enabling factor, especially when strong formal institutions are lacking, and the economically worst performing regions in Europe are the ones that have a devastating cocktail of weak formal and informal institutions.

Boschma and Capone (2015) also showed that national institutions matter for the types of diversification that prevail in countries. They found evidence that institutions that regulate less tightly labour, capital and product markets give countries more freedom to diversify in less related activities. This stands in contrast to institutions that coordinate more tightly such market relations, which push countries to diversify in more related activities diversification as their institutions make them stick more closely to what they have been doing in the past. Hence, national institutions matter as well, leading to different development logics channelled by national institutional environments.

1.4.3. DIFFUSION OF INNOVATION AND ECONOMIC CONVERGENCE

As we saw in the previous section, agglomeration trends and the determinants (or bottlenecks) for resilient and sustainable growth constitute the main concepts applicable to spatial distribution across regions, countries and continents. European convergence policy, however, is a special case for three reasons:

1. Although "regional", the policy in its largest share addresses entire countries (or large parts thereof as in the case of the Italian Mezzogiorno), which are persistently less competitive and suffer from low GDP per capita, low growth and unemployment. Their problems cannot be attributed to current agglomeration trends or at least not only to them. Lack of absorptive capacity, innovation-averse sets of institutions and low policy-making capacity are deeply rooted and path dependent. It takes national legislation and policies to break such path-dependencies.

2. Unlike middle income or developing countries globally the EU lagging countries benefit from transnational transfer of resources, which is unique, confirming that it is not lack of capital but the inability to transform that causes the persistent problems. Southern European countries benefitting for 30 years and Central and Eastern European Countries benefitting for 12 years are still systematically lagging behind: on the average their production structure and institutional capabilities have not changed or at least they have not changed in a way to ensure sustainable adaptation and growth. In many cases the crisis has shown that convergence trends can stop abruptly and reverse.

3. Policy has evolved over the years, recognising the need for more focus on R&I, supporting entrepreneurship and institutional change (mainly in the form of funding the modernisation of the public administration managing ESIFs).

In recent years convergence has continued in EU-28 but not in EU-15, indicating that the Southern countries are falling behind after the crisis, while only the very low income Member States continuing to converge (Cuadrado-Roura et al., 2016).

As we will highlight here, the increasing openness of science, innovation and the economy will lead in first instance to further centripetal forces and agglomeration. To brake the vicious circle in which many of the Southern and CEEC Member States are locked-in, they will need more radical, disruptive policies. Business as usual risks will not do, worse it will leave them further behind than in the past.

1.4.3.1. THE CHALLENGE OF BUSINESS R&D AND AGENTS OF CHANGE

In addition to the role of R&D for regional development and the conditions for successfully commercialising R&D results, mentioned in the previous section, it is important to distinguish further between the role of private and public R&D funding for the countries characterised by low competitiveness and persistent regional development. In the previous section, we already highlighted the huge differences between countries in the rate of return to both private and public R&D. With respect to cohesion countries and regions, one may note first and foremost, the low private funding and execution of R&D, on average below 50% of the EU average (Tsipouri, 2016).

This occurs within a context of those countries and regions receiving generous incentives being co-financed by European structural funds (ESIF). The picture is less homogenous in Central and Eastern European countries, where R&D employment in the business sector in Hungary, Slovenia and the Czech Republic has been outperforming the EU average thanks to significant increases in BERD over the last years (Havas, 2015). In summary: private R&D investments, which we know are profitable, are (with few exceptions), very limited in the convergence countries. Decades of incentives had limited impact.

Based on the empirical finding that R&D leads to jobs and growth and substituting low business R&D with public funding, convergence countries and the European Commission hoped to generate spillovers and growth. ESIF funds dedicated to R&I grew from 4% in the 1988-1993 Programming Period to 45% in 2014-2020 (Morgan K., 2015). Since the impact of public investments in R&D is not automatic, looking in more detail in what works is critical for countries dedicating almost half of their "ESIFs" to R&I. This is in line with the most recent all-encompassing evaluation of the effectiveness of EU Cohesion Policy (Bachtler et al, 2015).

Lessons from the past suggest that interventions that worked well in technologically advanced countries did not work equally well in the Convergence Member States. During the long period of supporting convergence some countries and some regions have been doing better than others. Effective spillovers are the theoretical underpinning of the differentiated performance. In practical terms one can argue that over the years, agents of change have emerged who in some cases were successful in penetrating and eroding the status quo, whereas in others they seem to have been killed by the system.

The lack of absorptive capacity was addressed primarily through the creation of intermediaries expected to generate research results which would spillover automatically. Policies were conceived to address "organizational thinness" (Tödling et al., 2005) via a variety of innovation intermediaries. They have emerged (and mushroomed) when R&I became a priority of regional funding. Their role was to address systemic failures (Smith, 2000), which were significant. They constituted a wide diversity of specific organisations, established or supported by regional authorities, with the purpose to care for companies' needs for innovation. Their proliferation and occasional deviation from their original mission led to "an urgent need to optimise a system that has in most cases grown in a somewhat anarchic way, lacking strategic governance. In many regions, both individual and collective effectiveness was then put into question" (Nauwelaers, 2011).

Intermediaries included a wide diversity of organizations such as technology transfer centres, university liaison offices business advisory bodies, technology or science parks, territorial agencies involved in innovation promotion, and more recently, networks or cluster management organisations. The academic literature on their performance in convergence countries is limited (unlike the rich empirical evidence in technology leading countries and followers that shapes the positive perception of intermediaries for spillovers), but rather critical:

- *Incubators*: Empirical research on business incubators shows that they face very challenging functions that are hard to implement effectively and not all of them do (Bruneel et al., 2012). On the contrary a large survey denotes that although the density of incubators in Europe is increasing "we also observed that there is still a long way to go: the business incubator continuum is unbalanced: merely the minority of the incubators invests in the tenants and provides real support. (Aerts et al., 2007)

- *Science and Technology Parks*: research in both advanced and convergence countries analysed the effect of location in an STP on firms' results and behaviour (Löfsten and Lindelöf, 2005, Fukugawa, 2006 and Squicciarini, 2008). In particular evidence from Southern Europe indicates scepticism. The effect on results is unclear; the empirical evidence shows that the likelihood of cooperation for innovation between firms and knowledge providers increases. (Rocío Vásquez-Urriagoa et al. 2016). Recent empirical evidence from Italy indicates that although the business situation of firms located in science and technology parks tends on average to be better than that of similar "non-park" firms, a difference-in-differences estimation shows that entering a science and technology park did not generally improve firms' business performance and their propensity to innovate compared with external counterparts (Liberati et al., 2015). Synergies between the on-park companies are limited only in commercial transactions and social interactions. The research type synergies are completely absent in all three parks (Baroukos et al., 2002). An initial study suggests a modest contribution of Science Parks and Business Incubators to economic growth in Portugal (Ratinho et al., 2010).

Convergence countries appear locked in a dead end, between organisational thinness on the one hand and the creation of intermediaries, who develop their own agenda and dynamism, deviating from their original mission, on the other. Only exceptionally they become agents of change. While created to facilitate the opening of innovation they seem to have been diverted from their most important work. Measurement of success is one reason of this deviation (Dalziel, 2010).

Supporting *networks and cluster* creation has been the response of regional programming to the lack of interaction and spillovers. Here again, there are success stories but by and large as it is inter-organisational arrangements (innovation systems, networks and clusters) that shape innovation processes and that compete in global markets, a shift from the traditional firm oriented perspective towards a more system-centred approach of innovation policy is required (Todling et Trippl, 2005).

Finally universities are another important agent with (potentially) widespread impacts at the local level. Almost all published studies show a very high local impact of the presence of universities, with a multiplier greater than one on average (Elliott, Levin and Meisel, 1988; Kott, 1987-88; Beeson and Montgomery, 1993; Blackwell, Cobb and Weinberg, 2002).

1.4.3.2. POCKETS OF EXCELLENCE

There is quite some evidence identifying "Pockets of Scientific Excellence" in the convergence countries. They are defined as a number of actors co-evolving to reach critical mass in specific scientific fields in regions or organisations, which have a narrow range of specialisation (Bonaccorsi, 2016). Thus, in less developed regions universities are able to excel (top decile) in 2-3% of the fields in which they are active, or in 12-13% (top three deciles) of these fields. Universities in less developed regions account for 11% of scientific fields of activity but only for 2-5% of excellent fields. In short: universities in cohesion regions are able to excel in a tiny number of scientific fields (2 to 5 fields in less developed regions). There are not more than 10 large generalist universities with a good number of excellent fields in EU less developed regions, while there are a number of small universities with a small number of excellent fields (but they have a high share of these fields out of their total activities) (Bonaccorsi et al., 2016)

This initial work suggests that scientific pockets of excellence exist in less-favoured regions, but that there are only very few and hence less likely to embark into interdisciplinary research or to act as a major attraction for private investment. In addition the political processes by which regional governments define their priorities involve the top levels of the academic system (Rector, Vice-rector) and business representation (Unions and Chambers). These represent the entire academic body and large established companies respectively, hence do not have many incentives to channel resources selectively to the pockets of excellence they may have. This is an explanation of the paradox by which Structural Funds are abundant, but good researchers often complain they are supported more by the FPs/ Horizon programs than by funding from ESIFs.

Universities are, however, agents of change for new firm creation. Based on the ETER census of all higher education institutions (European Tertiary Education Register), associated to data on publications from Scopus (Global Research Benchmarking System) for the period 2007-1010, an impact estimate was carried out taking into account all universities, all industries, in a large part of EU 28 countries. The findings are summarized in the box on p. 42.

Again, evidence from Italy clarifies the differentiated impacts depending on incentives, which play a significant role in promoting academic spinoff activity. The impact of overly-restrictive university rules regarding contract research has a negative effect on spinoff creation. (Muscio et al., 2015)

The extensive efforts of past intervention suggest that copying the intervention logic and concrete measures from technologically advanced countries had limited success. If this was the case in the past, the accelerated opening of science, innovation and markets has to avoid further aggravating the relative position of convergence countries.

1.4.3.3. GLOBAL VALUE CHAINS AND DIGITALISATION

Openness poses both a threat and an opportunity to convergence countries. The literature on Global Value Chains and Global innovation Networks converges in the conclusion that in order to reap the gains from value chain participation, countries must put in place the right kind of trade and investment policies (OECD, World Bank). Contracts do not come based on labour costs anymore; competencies count.

The same need for preparation applies to reaping the benefits of the digital transformation, i.e. reduced transaction costs, increased productivity and a positive contribution to economic growth, which will not be evenly distributed amongst either actors or space. The current digital transformation of services and

A direct estimate of the impact of universities on the growth of new firms in Europe

Data on firms *(source: Orbis)*
- new firms created in EU 28 in 2010 (n= 1.149.977)
- eliminated new firms which are controlled by other companies or public institutions
- n= 195.145 firms in 14 countries with full accounting information
- dependent variable = growth in total assets 2011-2014

Data on universities (sources: ETER and GRBS)
- all universities located in EU 28 countries
- four variables: publications, citations, citations per publication and share of publications in top journals (10% SNIP) by discipline (n= 251) in the period 2007-2010
- matrix of correspondence between scientific disciplines and industry sectors

Controls:
- level of total assets in 2011
- number of shareholders
- presence of venture capital
- GDP per capita at NUTS 2 level
- size of region (square Km)

Robustness check
- create a dummy/ eliminate top 10 regions by number of investments of venture capital (1998-2014)- results fully confirmed

Finding 1: Universities matter for start-up growth
- Strong effect of the presence of a university within a distance of 10 km from the firm
- Some effect until 25 km distance
- No impact after 25 km

Finding 2: The strongest impact on start-up growth is given by the quality of research
- Restricting the analysis to start-ups located within 10 km from universities, all variables of research activity have a positive impact on the growth of start-ups
- The strongest coefficient is found for the variable "share of publications of the university in top 10% journals"- a measure of research quality.

Source: Bonaccorsi, Colombo, Guerini and Rossi Lamastra (2016)

manufacturing inevitably requests "making choices in an inherently fluid and ever changing environment shaped by, to some degree, unpredictable technical change, and also social reaction to these changes" (Kenney et al., 2015). Digitalisation has been a major driver of changes throughout the value chain and many businesses recognise the need to adjust, but far fewer, especially among SMEs, are prepared for it (Smit et al., 2015). To take advantage of these changes countries need Infrastructure, Training and Skills, Social Protections and Regulatory Transitions (Kenney at al., 2015). But in terms of ICT export services, use of cloud computing and e-commerce, all Southern and Central and Eastern European countries rank low (OECD Digital Economy Outlook, 2015), with few exemptions in selected areas (OECD, Digital Outlook 2015). Besides, as demand for ICT specialists across all sectors has risen steadily, convergence countries may suffer from reinforced brain drain in well-paid highly demanded job outside their home country. Unless the less favoured regions (LFRs) enhance digital integration through investment in the fixed and mobile broadband infrastructure for industry and massive training, it is likely that openness will deprive them from traditional manufacturing and local skills.

Industry 4.0 (or the Internet of Things) is another high-tech area where LFRs are likely to fall behind. A study by the Brookings Institute (2015) identifies spatial concentration trends in Advanced Manufacturing in the US, while the corresponding studies in the EU clearly point out that the lagging countries can be distinguished into two categories, behind the front runners and "potentialists", both of them already supplying Germany with Industry 4.0 workers (Berger, 2014). First, the "Traditionalists" (Czech Republic, Slovakia, Slovenia, Hungary and Lithuania) have a sound industrial base but few initiatives to take them into the new industrial era. Some of these are already supplying German with Industry 4.0 workers. Second, the "Hesitators" (Southern and Eastern European countries (Italy, Spain, Estonia, Portugal, Poland, Croatia and Bulgaria) are considered not to have a reliable industrial base and suffer from sever fiscal problems that inhibit them from a future-orientation.

So impact between Member States will differ depending on their readiness to adopt new technologies and their general advancement in manufacturing. Industry 4.0 might also benefit remote or underdeveloped regions as technologies such as 3D printing make personalized, decentralised and local production possible (assuming the relevant pre-conditions are present) (Smit et al., 2015). As value chains become increasingly fragmented there are more entry points for new-comers, for example with regard to design, processing, handling customer data, etc., and more generally new ways of creating value and novel business models (Berger, 2015).

So in the global economy it might well be that LFRs spend resources, but others reap the benefit. There are many examples in that respect: migration of skilled workers or researchers to other countries or regions; relocation of start-ups or even established companies; innovative firms generating spillovers in favour of competitors located in the same geographical area through non-voluntary disclosure of technical information via social ties, mobility of workers and technicians, joint use of suppliers. Conversely a country may benefit from spillovers if adequately prepared: e.g. from knowledge generated abroad by hosting Foreign Direct Investments of multinational companies. Spillover effects take a variety of concrete forms and involve many agents at several levels of analysis (Goto and Suzuki, 1989; Los and Verspagen, 2000; Eberhardt, Helmers and Strauss, 2013).

1.4.4. CONCLUSIONS

An increasingly open knowledge economy such as that of the beginning of the 21st century, gives in theory the opportunity for knowledge to travel more efficiently and for innovation to happen virtually anywhere. But the sad truth is that this is far from being the case. Innovation has become more and more concentrated in 'innovation hubs' and many individuals, firms and regions are being left behind, with important consequences in terms of not only inclusiveness, but adequate use of existing resources and overall employment and growth generation.

The prosperity of cities and regions depends on their ability to absorb, develop and apply new knowledge. Yet, in a more open knowledge economy, new knowledge will not diffuse widely within and between regions, unless the absorptive capacity of individuals and firms as well as the regional institutions that bring agents together are improved. Knowledge will also spill over more intensively when regions are endowed with related industries that share similar capabilities. Having the right set of institutions may facilitate both the absorptive capacity and the adaptability of economic agents to transform knowledge into innovation and new economic activities.

Hence, in order to make the most of a more open knowledge system and to increase innovation and create jobs and growth across the European Union, active innovation policies that target absorptive capacity, related variety, and foster the formation of 'innovation-prone' institutions are needed. With a high quality of government and bridging social capital, cities and regions are more capable of turning knowledge into economic development. They can thereby maximise the benefits of open innovation and being open to the world, which can trickle down to the majority of the European population.

Southern, Central and Eastern European countries have benefitted from regional development support in general and support to R&I in particular in the past, using rather traditional ways of intervention with impacts below the expectations, in particular after the 2008 crisis. The accelerated agglomeration trends and the shift to openness are likely to be more challenging for these countries, which need to break with their past and call for more disruptive policies. In particular they need to go beyond a conservative approach and increase their readiness to embrace change. Openness will work to their benefit only if they precipitate change and adapt regional development policies. Otherwise they will lose their skilled labour force, their research results will become commercialized elsewhere and their already low attractiveness for investments will plummet even further.

Examples, aiming directly at such more disruptive policies may include:

- On R&I: empower agents of change, like pockets of excellence or successful start-ups, refraining from the long-established effort to distribute funds evenly and satisfying a larger share of applicants;
- On related variety: complement local deficiencies by taking advantage of the opportunities of globalisation instead of introversion; the business sector needs to network internationally rather than be kept in the national territory. This may oppose the traditional wisdom of proximity as the basis for spillovers networking and it complements lacking variety;
- Attack institutional inertia, which creates large delays and disincentives in the name of accountability: e.g. using lotteries and Innovation Voucher to cope with long times to contract, avoid too many intermediaries, reward high performance.

1.5 DIGITALISATION OF THE KNOWLEDGE-INNOVATION NEXUS

Willie Donnelly and K. Matthias Weber[9]

1.5.1 INTRODUCTION

The purpose of this last section of chapter 1 is to outline the conditions for a digitalisation of the Knowledge-Innovation nexus, which could address some of its current limitations. This objective is part of the broader development of an advanced open and digital economy in Europe with the capacity to compete globally and create markets for the future, with positive impact at local and regional levels.

In order to create markets for the future, Europe requires an open economy and society driven by digitalisation. Katz, Koutroumpis and Callorda (2014) defined digitalisation in a societal context as: 'the economic and social transformation triggered by the massive adoption of digital technologies to generate, process, share and transact information' (p. 32). The digitalisation of society is happening at a fast pace and both R&I policy and the Digital Agenda for Europe play significant roles in facilitating the process (Katz et al., 2014).

Kadar, Moise and Colomba (2014) highlight the impact that digitalisation has on all components of society and asserted the role of digitalisation for traditional industries whereby digitised design, production and distribution processes have led to substantially lower costs and the translation of goods which were once considered luxury goods into the mainstream marketplace. Constant innovation is required in the digital age in order for companies to maintain their competitiveness (Kadar et al., 2014). In other words, innovation is an integral and permanent activity in a digital economy. The impact of the globalised digital world has meant that there is a single economic system to be served by enterprises in current times (Kadar et al., 2014). In order to create open markets for the future, Europe must focus on fostering Open Innovation Ecosystems to take advantage of the growth possibilities for European enterprise.

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9) With input from RISE OI member Delphine Manceau and RISE OKM member João Caraça

Open innovation ecosystems are thus at the heart of a digital economy, consisting of all stakeholders – civil society, government, industry, academia, scientists, inventors, investors, citizens and researchers. They all incorporate embracing Open Science, Open Innovation and Open to the World. In nurturing open innovation ecosystems, it will be possible for regions to embrace innovation through the free flow of brain power, knowledge diffusion, trickle down effects and disruptive technology. This positioning will facilitate heightened engagement in Open Platform markets in an Open Economy which will allow the effects of openness permeate local European markets.

Digitalisation presents many opportunities for Europe, such as, increased productivity, competitiveness, and innovation in industry, alongside improvements in day-to-day quality of life in the development of health and sustainability measures regarding climate change, for instance. However, it also holds challenges in terms of Europe becoming 'disruption-ready', i.e. Europe needs be prepared to handle permanent, and often even disruptive economic change.

Europe is currently characterised as a highly fragmented, regulated market, where digital innovation cannot be taken up easily. While many European countries are performing well in terms of digital awareness, digital integration, connectivity and disruptive innovation, when considered collectively, the EU 28 requires significant development to prepare the conditions in which Europe can truly become an open, digital and innovative marketplace, where research and innovation are tightly embedded in supportive economic and regulatory frameworks. Moreover, people are the fundamental drivers of digitalisation and there will be significant developments required in order to ensure Europe keeps pace with more disruption-ready markets such as the US and China while defending its fundamental societal values. Infrastructural developments alongside positive policy and regulatory measures will need to occur. Governments must lead the way and embrace disruption in the provision of public services. Crucially, civil society must engage the skills gap to ensure that citizens have the relevant skills and knowledge to participate and work in the digital world.

In the subsequent sections we introduce a framework that captures the main determinants of the global digital markets, understood as a specific type of open innovation ecosystem. It serves as conceptual model to explain how global digital markets arise and make some companies successful, but also to point out how open innovation ecosystems could be fostered by European policy to enable the successful positioning of European firms on global digital markets (Section 1.5.2). Equally important from a policy perspective is taking care of the negative side-effects that a shift towards open innovation innovations may entail, and which need to be taken into account in policy (Section 1.5.3). This leads us to propose seven building blocks of what we call 'digital disruption management' (1.5.4).

1.5.2 THE CREATION OF GLOBAL DIGITAL MARKETS FOR THE FUTURE

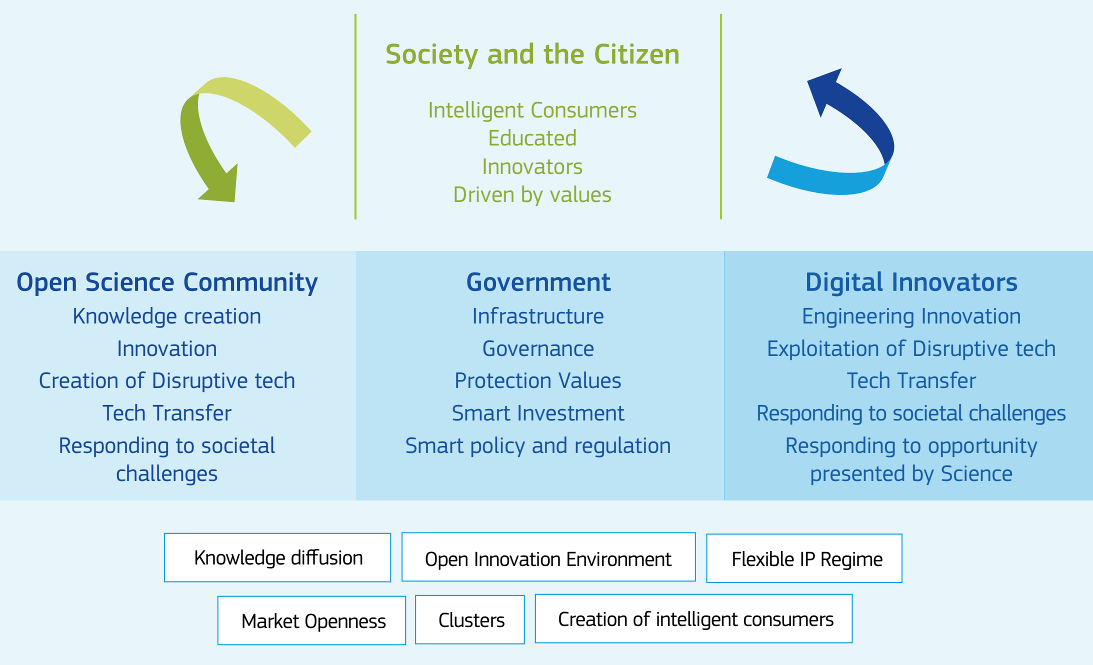
1.5.2.1. GLOBAL DIGITAL MARKETS AND THE ROLE OF OPEN INNOVATION ECOSYSTEMS

In order to realise the full potential of the digital economy in Europe, there is a requirement for all stakeholders to engage in the process. All members of the community, and not just the digital innovators, but civil society, the open science community and government too, must be equipped with the digital skills to take advantage of advanced technologies in line with broad societal values. The European Commission (2016) highlighted the necessity for people in the digital economy to obtain the skills to participate in disruptive technologies. The figure below conceptualises the global open and digital market as an open innovation ecosystem, which has, at its core, society and the needs and values of the citizens. This represents the ideal scenario for the digitalisation of the Knowledge-Innovation nexus.

However, there are also important concerns about the consequences of digitalisation within Europe. Some actors will be highly resistant to the changes brought about through digitalisation and barriers may be raised against disruptive technologies. There also exists a concern that Europe will be a fast follower of the open Digital Market paradigm and potentially disregard the needs and values of society to 'play the game'.

What is proposed in Figure I.9 is a conceptual framework for analysing global digital markets and for how Europe could become a leader of the global digital market which respects and behaves in line with societal and political values. Critical to this is the intelligent, educated

Figure I.9: Global Digital Market as an Open Innovation Ecosystem



Source: Authors

consumer in society who is an active participant in the digitalisation process, informing the activities of the open science, digital innovator and government communities. The conditions need to be put in place to ensure this fundamental position of society at the centre of the digitalisation process to maximise the positive opportunity of digitalisation and actively negate the negative consequences.

1.5.2.2. KEY CONDITIONS OF GLOBAL DIGITAL MARKETS

Berman and Marshall (2014) referred to the current generation as the time of 'digital disruption' where the focus of technological advancements has evolved from an organisational-centred to an individual-centred model with recent trends embracing an Everyone-to-Everyone (E2E) approach. Berman and Marshall (2014) identified three guiding principles for the E2E marketplace (p.14):

1. Organisations will only be as relevant as their ability to deliver the best experience through the right partnerships
2. The demand for data by contextual and predictive analytics will become insatiable
3. Open standards do not mean the end of intellectual property – successful organisations will protect what they do best and open up the rest

As highlighted by Berman and Marshall (2014), the realisation of digital disruption is only made possible by the maximisation of partnerships and relationships, fostering a community characterised by openness, collaboration and co-creation. This incorporates relationships between incumbent and emerging companies as well as relationships with research institutions and Higher Education Institutions, thus facilitating knowledge diffusion across industry and academia. The role of civil society and government is fundamental in ensuring the societal benefits are reaped in terms of participation in the Digital Economy and driving digitalisation in line with societal values.

Platform strategies are fast becoming the norm for enterprises in the Digital Economy. These strategies embrace collaboration and cooperation and maximise value. Gawer and Cusumano (2014) defined industry platforms as platforms that are created by a company that allow external firms to innovate on the platform and provide complementary or supplementary products, technologies or services to the offering. Example: Apple and the Appstore. There are thousands of developers creating apps for Apple products. Apple would not have the capacity to develop at this level in house and thus, benefit from the expertise and innovation of their collaborators and external developers.

1.5.2.3. OPEN INNOVATION ECOSYSTEMS IN THE DIGITAL ECONOMY

The European Commission (2016) report on science, research and innovation in the EU showed that the US consistently experiences higher levels of private investment in innovation than the EU. In Europe, both public and private investments are needed in order to reach goals of 3% R&D expenditure as a percentage of GDP by 2020. Effective use needs to be made of this investment in order to trigger economic activities in Europe. There is a need to focus on localising the benefits of the Digital Economy across Europe, for instance by fostering the absorptive capacity of regions and by enhancing the creation of new activities of related variety (see section 1.4). In order to ensure that all regions benefit, the adoption of the Open Innovation Ecosystems concept is recommended. Many regions lack the capacity for innovation but embracing the principles of Open Innovation can create a ripe environment for growth. O'Gorman and Donnelly (2016) describe the Open Innovation Ecosystem as requiring a number of "species" (firms, consumers, suppliers, R&D centres and supporting institutions). These are developed by a range of "nutrients" (entrepreneurial capacity, business acumen, risk capital, R&D enterprises, technology commercialisation, human capital, physical infrastructure, an industrial base, global linkages, networking opportunities, innovation culture, community mindset, capital, knowledge and technology transfer processes, professional services, support infrastructure, supportive government policies and a balanced quality of life). The successful operation of these ecosystems is characterised by trust, cooperation, collaboration and co-evolution.

In open innovation ecosystems, regions could become borderless. Examples of cross-border innovation across countries include, for instance, the Top Technology Region across Netherlands, Germany and Belgium. The capacity for international collaboration is increasing significantly with the development of new technologies and Europe must increase international activities within and beyond European countries to realise its innovative capacity. Traditionally, innovation occurred in 'closed' environments, the "not invented here" syndrome. Chesborough (2003) highlighted over a decade ago the benefits to be sought from companies leveraging external technologies as well as the benefits that can be sought in capitalising the externalisation of technologies created in-house. Europe must embrace Open Innovation and overcome "not invented here" syndrome for the digitalisation of industry and public services to realise open markets where Europe can be a genuine competitor as a single digital market.

The concept of smart cities as centres for innovation has gained ground in the digital economy. Schaffers et al. (2011) outlined the advancing role of cities in the development of urban as well as regional open innovation systems. Their paper addressed the concept of living labs within smart cities whereby advanced citizens are engaged in the experimentation and development of future technologies, harnessing the co-creation capabilities of society as cities and regions become more advanced, driven by smart technologies. Examples of European initiatives which have been launched include Wikicity in Rome, Real-time City Copenhagen and Visible City Amsterdam. European funding has also sponsored a number of smart city initiatives under the FP7 programme. The learning from these projects can be integrated into policy measures across Europe, supporting the development of smart cities and regions to promote the development/strengthening of public-private-people partnerships to drive open markets.

Knowledge diffusion is crucial in boosting the growth of future innovative markets (OECD, 2015). There are four factors highlighted to maximise diffusion: (1) the extension of global connections; (2) the ability to experiment with new technologies and business models; (3) direct resources (labour, capital, skills) to the most productive firms and; and (4) investment in innovation including R&D and skills to ensure the workforce have the capacity to embrace new technology. With a focus on openness, the development of communities of collaborators is increasingly encouraged. The European Commission (2016) highlighted positive performance in the EU regarding scientific outputs such as highly cited publications but recognized a limitation in the circulation of scientific knowledge and thus recommended further investment in initiatives which would enable inter-sectoral and international knowledge flow. In the spirit of encouraging the extension of global connections, Andrews and Criscuolo (2013) also highlighted the positive impact of the liberalisation of international trade to ensure the diffusion and adoption of novel technologies in new markets. Europe must become increasingly open to global influence to ensure pace is kept with innovation leaders such as the US and China.

In the development of open innovation ecosystems for future markets, business, government and civil society must all embrace digitalisation. Government has an important role to play by using the full spectrum of its instruments, and in particular of demand-side measures. The annual value of public procurement in Europe is €1.9 trillion. Digitalisation of public procurement via the electronic self-declaration for bidders (ESPD) and new, more inclusive rules for procurement is opening the market for SMEs who previously would have been unable to participate. eProcurement saves on average 5 % to 20 %, meaning more funds to be spent (5 % saving = €100 billion) across Europe. A significant portion of these procurements could also be used to trigger innovation by specifying ambitious targets and conditions for the products and services to be procured.

There are numerous policy and regulatory requirements for the creation of open innovation ecosystems. Firstly, the digitalisation of industry requires significant investment and thus policy must concentrate upon smart investment in order to publicly and privately fund innovation in this regard. The advancement of the technological infrastructure in the EU is imperative to the development of a single digital market capable of competing in the global digital economy.

The most competitive (high productivity) and resilient economies are the ones leveraging talent. With ICT disrupting traditional industries, those economies that equip their workers with the skills to participate in these technologies adapt best to the changing world (World Economic Forum, 2016). Investment in people and skills is thus paramount to ensure that civil society is capable of full participation in the digital economy (European Commission, 2016). Continued and further investment in tertiary education in the ICT domain is integral to maximising the employment opportunities of the digital economy as it is anticipated that by 2020, there will be 825,000 jobs which cannot be filled due to lack of skills.

The European Commission report on science, research and innovation performance recognised that there are a number of framework conditions required to foster innovation: i) It needs to be easy to start a business; ii) Legal systems need to be simplified; iii) Product market regulation needs to become more flexible (promoting competition, simplifying regulations and procedures); iv) Workforce regulation needs to facilitate skills development and reallocation of resources (shift in EPR needs to be adjusted to shift the "burden" from individual firms to society generally); v) IP rights protection must be increased and; (vi) Access to finance is fundamental (gap in VC availability between US and EU is 6:1 in terms of GDP[10]). The European finance markets have evolved over the last decade with many European countries in line with the US model of financing (Bijlsma and Zwart, 2013). However, the small financial systems of newer entrants to the EU alongside a number of countries such as Germany, Austria and Denmark, which have maintained the emphasis on bank-based markets, still require modernising to ensure finance markets which are disruption-ready and open to innovation.

Andrews and Criscuolo (2013) advocated the need for flexible product market regulations as they asserted it facilitates new entrants to the market which spur incumbents to be more innovative as well as promoting more efficiency in firms. They also highlighted the

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[10] A start has been made in this regard with the introduction of InnovFin for example, a funding mechanism by the European Investment Bank Group in cooperation with Horizon 2020: by 2020, InnovFin will make €24bn available in financing for research and innovation though this represents only a fraction of the investment required for the digitalisation of Europe

benefits to be sought in facilitating international trade and investment as knowledge and technology diffusion is heightened in this context, alongside the advantages of increased market size.

Innovation Deals[11] are an instrument designed to make Europe more competitive. They represent a mechanism for the flexible interpretation of legislation to remove barriers to innovation (as identified by stakeholders). Innovation deals for the Open Markets for the future should be negotiated between society, government and digital innovators, informed by the Open Science community to ensure societal focus to digital development.

Allowing for the development and roll out of disruptive technologies while protecting the rights of civil society requires Europe to devise a singular set of standards to make Europe more business friendly. Currently, Europe is characterised by "cyber-frontiers" whereby doing business with Europe means doing business with 28 different systems of regulation (Digital Europe, 2010)

Rüßmann et al. (2015) wrote a paper concerning the future of Industry 4.0 and highlighted the value of consortia such as PlattformIndustrie 4.0 and the Industrial Internet Consortium, in the development of standards for Industry 4.0. There are collaborations underway between PlattformIndustrie 4.0 and Alliance Industrie du Futur and the Industrial Internet Consortium to promote interoperability between architectures, emphasising the global nature of the collaboration possible in Open technology.

1.5.3. DETRIMENTAL EFFECTS OF DIGITALISATION FOR ECONOMY AND SOCIETY

As a disruptive process, digitalisation and the opening up of innovation activities will inevitably create 'friction zones', i.e. areas where tensions between established and newly emerging practices arise. They are likely to create at least temporary negative consequences, either for the individual (who may lose his or her job) or at collective level (e.g. in terms of declining industries and sectors). The Commission's commitment to Open Innovation, Open Science, and Open to the World (European Commission 2016) requires policy measures which will represent significant change for citizens and society, but also great opportunity in a digitalised world if such frictions can be overcome. These kinds of frictions and tensions are quite common in periods of structural change and adjustment, but what is new as compared to previous periods is the speed at which digitalisation transforms economic and social life. Counter-measures and adjustments need to take place quickly. Without being exhaustive, the main areas where we can already now observe such frictions arising are:

- ***Jobs and labour:***

A lot of uncertainty is associated to the question of whether digitalisation will create more jobs than it destroys, or not. Recent studies rely on strong, sometimes questionable assumptions regarding the degree to which robots or other kinds of artificial intelligence will replace existing jobs (e.g. Boston Consulting Group, 2015; Roland Berger, 2016; IAB, 2015; WEF, 2016), thus giving rise to alarmist as well as comforting outlooks. In general, we tend to lack the necessary imagination to anticipate the new types of jobs that might be created by digitalisation. Currently, most studies – though with widely diverging projections – are expecting a net loss of jobs, of course depending also on the extent to which countries or regions are 'disruption-ready' or not. This, in turn, raises issues such as emerging new social divides between those who have (better) jobs and those who will lose theirs (or only keep precarious ones), new ways of redistributing wealth in society, and the importance of – paid or unpaid – work for individual's self-esteem and identity.

- ***Education and training:***

In a world increasingly characterised by globalisation, the educational system in Europe has begun to evolve to provide education and skills to students of European higher education institutions that are internationally recognised and valued. The European Commission (2015) is committed to the development of the European Higher Education Area (EHEA) in line with the Bologna process. Aguilera-Barchet (2012) reported that the key difference between the European and US higher education systems is in the focus in the US on research and applied research whereas traditionally, European education was more focussed on instruction. Additionally, the US system was designed to equip students with specific skills to make them more employable. With the shifts in jobs and labour identified

[11] See: https://ec.europa.eu/research/innovation-deals/index.cfm?pg=home

in the previous point, it will be increasingly necessary for the education systems to evolve and equip individuals with the skills and flexibility required to be employed or create employment in the digital economy. In this context, the emergence of a new digital divide needs to be avoided. Already at schooling age, important foundations are laid to help avoid such a divide from arising. And a later career stages, the ability and willingness to learn will remain crucial.

- ***Shifts in the location of value creation:***

Economic value creation increasingly takes place in global value networks. Being part of these global networks is essential for participating in the new digitalised economy, and openness to the world is a pre-condition for this. The key issue in this regard is how to ensure that a substantial part of that value creation continues to be to the benefit of EU-based firms and thus to its citizens. This raises the question of what kinds of activities will create value in the future, and where. As shown by several of the most successful global players in the digital economy (e.g. Apple and others), intellectual property, the control over platforms, and other intangible assets have turned into main sources of value creation, thus further attracting other complementary activities (see OECD, 2015). The US (or at least some locations in the US), but also China (though possibly with a more limited global outreach) seem to be in a better position than Europe in creating these kinds of new business around IP and platforms, and thus in building major poles of attraction for investment. This entails the possibility of a reinforcement of the economic power of the US and China due to their ability to capture value in global networks by controlling digital platforms and IP. The innovation ecosystems around major cities have an important role to play as hubs in global networks, which help ensure that value-creating activities are spatially bound.

- ***Regulation and framework conditions:***

Digitalisation and platforms challenge a range of highly regulated sectors, and thus the standards and stability built over past decades. The most well-known example is without doubt Uber, which is shaking up the market of taxi services, and AirB'nB as an alternative to traditional accommodation services. Regulation and framework conditions play an ambivalent role in this regard: on the one hand, they need to be flexible and open in order to accommodate for the emergence of new digital and open services, but on the other hand they need to be sufficiently stable to provide a reliable basis for investment into new kinds of businesses. Moreover, existing regulations, such as in the taxi business, once served to secure safety standards, working conditions and reliable income, but they have evolved into barriers to competition. The key issue is how to manage the transition from the 'old' to the 'new' regime, but without triggering a race to the bottom. Recent empirical studies from the US, show that the 'brave new world' of jobs in the digital platform economy does not offer sustainable employment and reliable income, but is regarded as either a top-up or a temporary source of income (Kenney and Zysman, 2015; Schoor, 2014; Frenken et al., 2015). In the development of the Single Digital Market, aligning the regulations of national sovereignties within Europe to realise a singular system whereby interoperability and compatibility will facilitate 'doing business' with Europe will be key. Additionally, regulation and policy will require the flexibility to adapt to global markets and regulations to ensure Europe as an active participant in the Global economy.

- ***Values, privacy and cyber security:***

Privacy is a major issue of concern in many European countries, and it is critical for the success of the digital economy. The emergence of new digital markets may easily be hampered by privacy concerns, and for good reasons, but at the same time many digital services are not viable without access to personal data of consumers. Similarly, security concerns are another major factor preventing firms from adopting advanced Industry 4.0 solutions. These issues affects not only those business models that rely on targeted and personalised publicity (e.g. Google), but also the provision of advanced health services, including electronic health records of patients as well as big data analytics to provide more personalized treatments. In general, privacy and security are just examples of societal values that need careful balancing with other goals in the digital economy. Further value-related debates are likely to arise, for instance in relation to employment, the relationship between humans and robots, or newly arising digital divides.

1.5.4. CONCLUSIONS

The challenge for policy consists of making society more 'disruption-ready'. This does not mean that we should just accommodate for and embrace digital disruptions as they arise, but rather that we prepare for responding quickly to disruptive developments and modulate the emerging transformation in line with the core goals and values we want to pursue (Kemp et al., 2007). This requires, of course, a shared understanding in society of what these core goals and values are, and which ones might be threatened by the emerging disruption. Recent developments in many European countries underline that eroding cohesion and deepening social disparities are a major concern for citizens to which governments need to find a response in a time of disruptive digital change.

Complementary to the more established notion of transition management (Geels, 2015), which is suitable for slow and long-term transformations of socio-technical systems, we suggest developing what we might call 'digital disruption management'. It implies (at least) the following seven building blocks:

1. *Creating and enabling the necessary synergies and complementarities to unleash the potential of open digital markets in Europe*: For policy, this implies first of all removing barriers to innovation, but also to the creation and growth of digital business. In particular, the entry and exit conditions of established markets, where digital start-ups challenge incumbents require close attention. Policy strategies may also have to enable the establishment of standards, shape framework conditions (e.g. regarding IP), or facilitate the dialogue between stakeholders. Europe needs to lead on digital ethics to support the creation of solutions that embrace European social and political values; values that are citizen-centric, for instance in relation to privacy and security concerns. Europe needs to lead the global market for ethical and society-centric digitalisation, if cities are to embrace the Open Innovation Ecosystem ethos. This should foster the development of Global Digital leaders in Europe whose entrepreneurial efforts are in response to the needs of society and enabled by the Open Science community.

2. *Enhancing the ability to adapt to fast and uncertain change by building resilience of individuals and organisations*: This building block requires a strengthening of education policies to endow young as well as older people with the necessary skills and competencies to keep pace with the digital economy, and ultimately to advance with the changing requirements of their jobs. Moreover, both private and public sector organisations (e.g. ministries and agency) need to become more agile and open in order to keep up to the requirements of the open digital economy. Encouraging digital balance across Europe could be facilitated through the utilisation of Regional Development Funds and Infrastructure funds at regional levels to facilitate digital access to the tools to participate to enable early adoption and consumption of digital technology across society

3. *Ensuring that new value-creating activities in the open digital economy are embedded and rooted in countries, regions, organisations and institutions in Europe*: From a policy perspective, this building block calls for creating Open Innovation Ecosystems that address matters of supportive framework conditions, as well as a well-trained labour force able to handle an open digital economy in all its facets. Cities play an important role as contexts in which many developments in the open and digital economy are embedded. Supporting international and inter-sectoral knowledge flow will enhance knowledge diffusion in regions and promote communities, which include the citizen, government, incumbent industry as well as emerging industry. The control of digital platform as value-creating devices should not be underestimated either and needs to be taken into account in policy strategy.

4. *Governing the change process in a desirable direction and avoiding major negative consequences*: Digitalisation and openness should not be taken for granted, but they need to be actively shaped around common views about what values we want to maintain in society. This points to a need for truly participatory and open governance processes in order to provide orientation for the direction to take, but also to take care of trade-offs and frictions. Policy has a very important role to play in this regard, in charge of triggering debate, building a widely shared opinion on the direction to take, balancing winners and losers of the change process, and taking care of overarching societal concerns. This fosters a governance model of responsiveness to disruption harnessed by policy development, which is reflexive, realistic and consistent in order to embrace disruption and bring about positive change in line with overarching societal values.

Flexibility in policy and regulation must be embraced in order to keep pace with the rate of technological development. Governments need to share best practice and allow the open flow of ideas to embrace innovation.

5. *Imagining the new types of jobs that may emerge in the digital economy*: Spearheading the creation of new employment will be decisive for securing support by the public for policies aiming to foster the digital economy. There are several studies indicating the types of jobs that may either be substituted by automation and robotics, or at least be heavily affected by it. In contrast, we know very little about the types of jobs that might be created in the course of the digitalisation of the economy. Nurturing the creativity of ideating new needs and professions, and making visionary ideas about future jobs known falls under the responsibility of a new generation of labour market policies, together with the provision of the necessary curricula and trainings to prepare for them.

6. *Experimenting with new policy and governance approaches*: A more flexible and experimental approach to governance (experimental regulation, innovation deals, innovative IP arrangements, etc.) and the formation of new policy instruments is needed in order to handle processes of disruptive change. For example, the patent environment in Europe currently represents a barrier to entry in many cases due to the associated costs. Engaging in more flexible and open IP policies will leverage European investment, promoting trans-disciplinary flow of knowledge to take innovative ideas out of silos (e.g. 'smart-agri' application of ICT to agriculture). It also implies making use of the full spectrum of policy instruments (from R&D funding to smart regulation to Government as a lead provider and user of open digital services) to frame the disruptive change process and to handle potentially negative consequences of digitalisation. Moreover, an experimental approach to governance will inevitably give rise to frictions between different policy instruments, not least between those addressing open science, open innovation and open markets. Learning about these frictions and adjusting the experimental instruments will be essential to end up with a robust and coherent policy package at the very end.

7. *Advancing and promoting a European way of regulating the digital economy*: Regulation regarding privacy and cyber security protection must be designed to facilitate the development of the digital economy in a safe way for European citizens, in line with European citizens' values. The effectiveness of such protection is dependent upon the ability of Europe to provide leadership in this regard to the global community. The ability of European entrepreneurs and industry to develop global products that articulate the benefits of such regulation to the global community is key. Due to the integral nature of innovation in the digital economy, new regulatory inroads need to be designed early on in the innovation process, thus calling for a closer coordination between digital single market and R&I policies.

1.6 POLICY IMPLICATIONS

Luc Soete

Starting with the discussion in the first section of this Chapter on "national system of innovation", the recognition that R&D policies alone will not facilitate the diffusion and assimilation of knowledge in an open economy, implies that complementarities and synergies between a large set of very different policy fields will be essential for reaping the full benefits from the 3 O's. Four areas appear at the outset essential for a well-functioning "national" system of innovation.

First and foremost the investment in human capital: the cement, one could argue, that keeps the knowledge and innovation system together. Higher education is crucial for the continuous feeding of fundamental and applied research. Second: investment in research and innovation more broadly. In an ideal synergetic interaction with human capital, research and innovation will act like yeast to increase productivity across the economy, while other factors such as a technological breakthrough or a disruptive innovation might suddenly mushroom increasing productivity much more dramatically in some market niches, some sectors or some firms, than in others. The third "node" holding knowledge together within the framework of increasingly "open" national systems of innovation is geographical proximity. The regional clustering of industrial activities based on the close interactions between suppliers and users, involving learning networks of various sorts between firms and between public and private players, represents a more flexible, open and dynamic organisational set-up than the organisation of such learning activities confined within the contours of individual firms. The fourth and last notion essential to any innovation system approach is the 'absorptive capacity' discussed at greater length in the third and fourth sections of this Chapter.

Following this framework, it will be clear that the European policy challenge is that the governance mode for each of these key nodes has historically grown in different directions. Let us briefly discuss each one of those through the new lenses of the potential economic impact of the 3 O's as reviewed above in the previous sections.

Higher education, the first node has remained first and foremost a nationally organized and funded activity even though curricula, evaluation and accreditation of an increasing number of study fields became increasingly internationally organised. Over the last decades students in Europe and beyond have become partially mobile thanks to the Erasmus programs and the Bologna reforms with the growing transparency of the amount of study points allocated to studies abroad. At the same time, education should pay more attention to enhance the ability to adapt to fast and uncertain change so as to endow young but also older people with the necessary skills and competencies to keep pace with the open digital economy. In short, education is becoming both from the perspective of content and mobility much more "open". However, national (regional in those federal member states where higher education is governed at the regional level) governments have remained both in terms of administering as well as in terms of financing in total control, with particularly in some of Europe's less favoured regions a negative impact on growth dynamics as discussed in section 4. A solution could be that on a voluntary base, within each MS, universities are given the opportunity to apply for a European statute, as proposed in Ritzen and Soete (2011).

Public research funding, part of the second node in the national innovation system approach, is by contrast governed, as defined in the Lisbon Treaty, in a "shared" way: at individual Member States (MS) level and at European level. The current existence of the ERC e.g. next to 27+ individual MS' research councils each with their own specific national rules and regulations often defined by geographical boundaries appears from an overall European perspective not very efficient. Research excellence is in many areas dependent on scale. The flurry of individual MS' plans for achieving research excellence in new, emerging popular areas provides in many ways a good example of a "locational tournament" in Europe with as a result an inefficient allocation of national public research funds. From this perspective, the EU does not reap the full benefits from its R&I investments, neither at national nor at European level. Again the "openness" framework challenges the closed nature of national public funding research allocation. Therefore, European research policy could evolve gradually into a Common Research Policy (CRP) with MS integrating parts of their national research programmes under such a CRP structure, with some "just retour" set of rules, opening up further national research programmes and increasing the mobility of researchers in Europe. It is interesting to note that research integration has always been considered one of the core areas for European integration, even at the time of the early days of the European Coal and Steel Community (ECSC).

In the new 3 O's research and innovation landscape, applied research, technology transfer, the use and re-use of "foreign" technology as well as innovation and entrepreneurship, the third node identified above, have a strong regional and local focus. As was argued in section 4, promoting related industries that share similar capabilities in neighbouring areas of Europe will allow knowledge to spill-over more intensively in an open economy. At the same time concentrating on such 'innovation hubs' might also leave many individuals, firms and regions behind. The goal of policy should therefore not be to make the economic structure of regions more specialized (i.e. less diversified), but instead to leverage specific strengths, to identify hidden opportunities and generate platforms upon which regions can build dynamic forms of competitive advantage. Openness in this context means that policy should also focus on activities that are not yet present in the region but which have the potential to increase the potential of the region to generate high benefits at relatively low risks given the high amount of local activities already "related" to these new activities.

Challenging the fourth node, "openness" brings to the forefront the major differences in the absorptive capacity between MS and cohesion regions, highlighting the need for active innovation policies that target such absorptive capacity and foster the formation of 'innovation-prone' institutions. In a more open knowledge economy, this can only be achieved if the institutions, like high quality of government and bridging social capital that facilitate the absorptive capacity of individuals and firms, address the complexity involved in the production and the delivery of services. The more complex economies, the more capable they are to make the high value added complex products that combine many different pieces of knowledge, which are hard to copy or imitate by other economies. How to enhance such complexity? In our view, the area of procurement and supply chain has still untapped potential. As argued in section 1.2, policy measures to harness public procurement in support of innovation such as the Lead Market Initiative are now reasonably well-established, but require scaling-up. What is lacking are measures to incentivise private procurers, normally those at the top of a supply chain, to be more demanding in terms of requesting innovative solutions. Therefore, in several "grand challenges" areas, innovation platforms should be designed to bring suppliers and users together and engage them in joint horizon-scanning activities, addressing such complexities. To counter the issue of risk aversion with procures one could think of an 'insurance' approach whereby public funding is used to offset the costs of having to revert to an off-the-shelf solution if the intended supplier innovation does not materialise. This policy instrument could be an important adjunct for the European Innovation Council as it would provide a first track to the critical first market application for innovative companies receiving R&D support.

Finally, and as highlighted in section 5, there is the issue of creating and enabling the synergies and complementarities unleashing the potential of open digital markets in Europe. This implies of course removing the many barriers to innovation as will be discussed at much greater length in Chapter 4, but also to the creation and growth of digital business. In particular the entry and exit conditions of established markets, where incumbents may be challenged by digital start-ups require close attention. Policy strategies may also have to enable the establishment of standards, shape framework conditions (e.g. regarding IP), or facilitate the dialogue between stakeholders. In the spirit of the 3 O's, Europe needs to lead on digital ethics to support the creation of solutions which embrace social and political values which are citizen-centric. Europe also needs to lead the global market for ethical digitalisation which is society-centric with society embracing the Open Innovation Ecosystem ethos. This should foster the development of Global Digital leaders in Europe whose entrepreneurial efforts are in response to the needs of society and enabled by the Open Science community. Digitalisation and openness should, however, not be taken for granted, but will need to be actively shaped around common views about what values we want to maintain in society. This points to truly participatory and open processes to provide orientation for the direction to take, but also to take care of "trade-offs" and "frictions". Policy has an important role to play in this regard, in charge of triggering debate, building a widely shared opinion on the direction to take, balancing winners and losers of the change process, and taking care of overarching societal concerns. This fosters a governance model of responsiveness to disruption harnessed by policy development which is reflexive, realistic and consistent in order to embrace disruption which brings about positive change in line with overarching societal values.

Chapter 2:

Open Science

TABLE OF CONTENTS

2.1 Introduction....59

2.2 Open science: A framework to foster quality of research....60
- 2.2.1. Introduction....60
- 2.2.2. Towards a definition of Open Science....61
- 2.2.3. The EU way towards Open Access to scientific publications, data and metadata....61
- 2.2.4. Strengthen dialogue between science and society: Science with and for Society....62
- 2.2.5. Link scientists to science policy making....63
- 2.2.6. Developing proper e-infrastructures, digital tools, services, and legal and policy requirements for Open Science....63
- 2.2.7. Human Resources: Skilled people for openness and Research Integrity....64
- 2.2.8. Final Remarks....65

2.3 Funding and Career Advancement in an Open Science Environment....65
- 2.3.1. Removing Barriers to Open Science....65
- 2.3.2. Extreme competition for limited resources is a barrier to openness....66
- 2.3.3. Current incentive structures create barriers to Open Science....68
- 2.3.4. Changes for consideration in funding to promote Open Science....69
- 2.3.5. Europe has an opportunity to lead the way on Open Science....72

2.4 Scholarly publishing and peer-reviewing in open access....73
- 2.4.1. Introduction....73
- 2.4.2. Researchers should own the peer-reviewed journals they create....73
- 2.4.3. Researchers need publicly-owned and open source publishing platforms....77
- 2.4.4. Open peer reviewing improves the reproducibility of published results....80

2.5 Open Data: Challenges for implementation and possible solutions....82
- 2.5.1. Introduction....82
- 2.5.2. Core Challenge One: Competence in Working with Data....82
- 2.5.3. Core Challenge Two: Appropriate Infrastructure for Open Data....84
- 2.5.4. Core Challenge Three: Creating a Supporting Culture for Openness....85

2.6 Open Science and Research Integrity....87
- 2.6.1. Introduction....87
- 2.6.2. Defining research integrity....87
- 2.6.3. The impact of loss of research integrity....88
- 2.6.4. How can research integrity be ensured?....88

2.7 Policy implications....92

CHAPTER 2
OPEN SCIENCE

2.1 INTRODUCTION[12]

Mary Ritter

Our society faces many complex global problems, such as climate change, health and energy. To address these shared problems, we need a new shared approach to the generation of knowledge, whilst also building a sustainable economy. Open Science provides such an approach. It provides a deep change in the scientific environment in both knowledge creation and dissemination, bringing science to be more open, accessible, global, transparent, integral, collaborative, and closer to citizens. This is inherently good for the quality of science and for improving the efficiency of R&I systems[13].

There is strong historical precedent for this Open Science approach. It has been argued by Joel Mokyr (2016) that it was the combination of European culture coupled to technological advance (new knowledge), that enabled the Industrial Revolution to start in Europe – enabling the economies of Europe to flourish. Innovative technology alone in other parts of the world was insufficient. Thus, the determining factor underlying this 'geography of innovation' in the 18th and 19th centuries is likely to have been the European Age of Enlightenment – with its emphasis on reason, logic, criticism and freedom of thought, and where people from different walks of life came together to discuss and share knowledge. The importance of this dual influence – new knowledge combined with open sharing and dissemination of this knowledge – is a key message for us today in the development and support of Open Science, leading to high impact innovation and the downstream economic benefits arising from this.

Europe, with its world-leading research and knowledge base together with its culture and ability to share knowledge and activities across many national boundaries, therefore has a great opportunity to lead the world in this new Open Science way of working, and indeed is already making major strides[14]. However, to fully implement Open Science we need to identify the hurdles that currently stand in its way, and we need to develop novel ways to overcome them[15].

If Open Science is based upon the open sharing and dissemination of knowledge, the successful practice of Open Science is critically dependent upon the quality of the knowledge and the efficacy of the sharing and diffusion mechanisms. Thus, it will be influenced by factors affecting the generation of new knowledge: attracting first class young scientists to careers in research; developing appropriate ways to assess the quality of research and to award funding, avoiding the easy use of numerical proxies; and ensuring a culture of research integrity. It will also be influenced by factors affecting sharing and dissemination: knowledge must be available for use not only by those who create it, but

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12) RISE Open Science Group with its members Mary Ritter (chair), Megan Carey, Julio Celis, Marie Farge, Dainius Pavalkis, Teresa Riera and EC colleagues: Vita Crivello and Silvia Luber, first came together in January 2016, to discuss and define the barriers to Open Science and to allocate responsibilities between the six group members. Work was followed up via a series of draft documents, email correspondence and three further face-to-face meetings. A key input and highlight of the work was the group's two-day workshop entitled Open Science: a framework for accessibility, transparency and integrity of scientific research, held in Palma, Mallorca. This brought together the RISE group and 12 invited external specialists for a dual purpose: first, to participate in a public open debate focusing on: 'Open Access and Open Data' and 'Promoting a culture of Research Integrity for Open Science: Funding Models and Career advancement in an Open Science environment', and second, to have a detailed working discussion in private with the RISE group. The public session provided high-level input and exchange of ideas from a wide range of participants, while the private session with the invited specialists enabled a detailed discussion and critique of the analysis and recommendations on Open Science that the group was developing for Commissioner Moedas. The key outcomes of the Mallorca workshop were brought together in a formal declaration – the Mallorca Declaration, which can be found as an appendix to this book.

13) For details see section 2.2; also Commissioner Moedas's Open Innovation, Open Science, Open to the World – a vision for Europe.

14) for example, the proposed EU Open Cloud.

15) The key outcomes of the Mallorca workshop have been brought together in a formal declaration – the Mallorca Declaration – which has been endorsed by all workshop participants. This is included at the end of this Book (APPENDIX 1).

by many other actors – as pointed out in Chapter 1 of this book, 'the openness paradigm has at its core the increased flow of knowledge between organisations'; individuals and their organisations must know how to use this open knowledge – i.e. 'open data'.

In this Chapter the focus is on five key issues and barriers concerning Open Science. Open Science as framework to foster quality research (section 2.2); its funding and career advancement implications (section 2.3); the consequences for publishing and open access (section 2.4); the challenges of Open Data and last, but not least, the question of research integrity (section 2.6)[16].

[16] *Additional input, focusing on the inter-linkages between the 3 O's rather than OS per se, was also produced and can be found in APPENDIX 2 to the Book where two case studies are presented. The first, Funding Mechanisms: A Case Study on Translational Oncology in the World of Open Science, Open Innovation and Open to the World, authored by Julio Celis and Dainius Pavalkis, provides an example of how to build research ecosystems where the three strategic priorities established by Commissioner Carlos Moedas could develop and progress in accord to tackle a major societal challenge. The second, Climate-KIC: A Model for Open Innovation that is Open to the World, authored by Mary Ritter, presents a cross-sectoral European Knowledge Innovation Community (KIC) model of open innovation which builds on the output from open science and provides a platform for global collaboration. An integrated innovation framework takes scientific output through to application, commercialisation and the market, leading to societal and economic impact – thus supporting the 3 O's vision for Europe.*

2.2 OPEN SCIENCE: A FRAMEWORK TO FOSTER QUALITY OF RESEARCH

Teresa Riera Madurell

2.2.1. INTRODUCTION

Open Science (OS) is a term that mainly evokes a deep change in the scientific environment on both knowledge creation and dissemination towards a public funded science to be more open, accessible, global, transparent, integral, reliable, collaborative, and closer to citizens. This is inherently good for the quality of science and for improving the efficiency of our R&I system.

Because of that, OS is for the EU a fundamental political goal, as, in a knowledge-based economy, advantages come from being competitive on knowledge production and use. Then, quality research enhances competitiveness which is crucial for economic growth and job creation. But quality research and innovation benefits are not restricted to economic growth. Knowledge is also the primary instrument for identifying and resolving serious challenges of global reach with which mankind is confronted, such as climate change, water management, energy supply, cyber security, poverty or epidemics, that compromise, to a large extent, the survival prospects of future generations (Salmi, 2015).

Moreover, OS also implicitly refers to new incentives and practices to be more aligned with the democratic rights and values, ranging from the democratic right to access publicly funded knowledge, the development of freely available tools for collaboration, transparency or integrity, to the need to bridge the gap between science and society. According to (Guédon, 2016), *the application of the term "open" to science means that something is actually missing, as science should be open by definition! So, Open Science is a tautology. The new definition would be: "Free science", a science between freely trusted collaborators that contribute to produce research results solid enough to have a solid basis. Quality would then be derived from trust.*

The development of new ICT tools involves an increasing digitisation of research that opens more and more opportunities for public founded science to be more open, accessible, global, transparent, collaborative and closer to citizens.

2.2.2. TOWARDS A DEFINITION OF OPEN SCIENCE

There are in fact multiple approaches to the term and definition of Open Science, (Neylon and Wu, 2009; Gezelter, 2009; Fecher and Friesike, 2013; Bueno de la Fuente, 2014) that could be synthesized and structured by proposing that OS means, at least: "Fair open access to scientific peer reviewed publications", "open access to data and metadata", "Open Sources" and "Open Notebooks". These are just simple ways of referring to four major goals:

1. Public accessibility and full transparency of scientific communication;
2. Public availability and reusability of scientific data;
3. Transparency in experimental methodology, observation, and collection of data;
4. Complete scientific collaboration.

Four essential needs closely linked to the previous four fundamental goals fall, also, into the boundaries of Open Science:

5. Strengthen dialogue between science and society;
6. Linking scientists to science policy making;
7. Developing proper e-infrastructures, digital tools and services for OS;
8. Changing legal tools and policy requirements for open science.

None of this is possible without taking the necessary steps to build the new structure of OS on solid foundation and values by:

9. Preparing skilled people for openness;
10. Demanding a responsible conduct to researchers, intrinsic to the values of research and the trust it engenders: Research Integrity.

In order to achieve all these objectives, proper initiatives have to be taken after answering two key questions: what barriers have to be removed to gaining widespread support for OS and how can our R&I system be designed or modified to make these goals the natural state of affairs for scientists? For some of the stated objectives, the key questions will be widely answered in the excellent contributions of my colleagues in this publication. Next, I will do some more general consideration on some of those objectives.

2.2.3. THE EU WAY TOWARDS OPEN ACCESS TO SCIENTIFIC PUBLICATIONS, DATA AND METADATA

Although since 2008 there was an Open Access Pilot Project under FP7 (EC, 2016c) Open access to scientific peer reviewed publications and to research data was established as an underlying principle in Horizon 2020. Thus, Article 18 of the H2020 regulation says:

1. *Open access to scientific publications resulting from publicly funded research under Horizon 2020 shall be ensured. It shall be implemented in accordance with Regulation (EU) No 1290/2013.*
2. *Open access to research data resulting from publicly funded research under Horizon 2020 shall be promoted. It shall be implemented in accordance with Regulation (EU) No 1290/2013.*

Since different stakeholders were in different situations and have different needs, two non-mutually exclusive ways of arriving at open access to publications were considered for its implementation during, what was considered, a transition period: Green Open Access and Gold Open Access (Kelly, 2014; EC, 2016d)

Nowadays, benefits from open access to scientific peer reviewed publications, data, and metadata have been demonstrated and more widely recognized. With open access: 1) progress has proven to be faster, as researchers can know and use others' findings without restriction, leading to increased returns on science investments; 2) duplication of research efforts are avoided, leading to savings in R&D expenditure; 3) opportunities for multi-disciplinary research are enhanced, as well as inter-institutional and inter-sectorial collaborations; 4) broader and faster opportunities are given for adoption and commercialization; 5) education is improved, as students have access to the latest global research findings; and 6) taxpayers are allowed to see the result of their investment. The development of internet and electronic publishing has opened unprecedented possibilities for the dissemination and exchange of information.

Then, it is the right time to move a step forward to a more advanced model, as Marie Farge suggests in her contribution to this publication "Publishing and peer reviewing in open access", in which:

1. Research aims to be a continuum, with researchers owning the intellectual property that they create, and recovering control of their journals, with publishers becoming service providers. Researchers should also be informed about the publication system and its cost.
2. The quality and the reproducibility of published results are improved, and
3. Green and diamond open access models (Hoorn, 2014; Kelly, 2014) proposed by researchers are developed, where researchers own the journals they create, where publicly-owned platforms are needed to experiment new ways of publishing their results, and where open peer review should be developed to improve the reproducibility and integrity of research.

Open Access to scientific data and metadata, available without restrictions on re-use, also benefits the progress of science, as it allows sharing information; an extensive experimentation and model evaluation; and increases the transparency of the research process. Under Horizon 2020 a pilot action to open access to research data in projects has been launched (EC, 2016e).

As it was already agreed by the OECD members on (OECD, 2007) it has to be endorsed that: *Openness means access on equal terms for the international research community at the lowest possible cost, preferably at no more than the marginal cost of dissemination. Open access to research data from public funding should be easy, timely, user-friendly and preferably Internet-based.*

In April 2016, the Dutch EU Presidency hosted an Open Science Conference in Amsterdam. The Amsterdam Call for Action on Open Science (European Council, 2016) advocates for "full open access for all scientific publications", and endorses an environment where "data sharing and stewardship is the default approach for all publicly funded research".

Barriers to Open Access still existing are a direct result of funding and rewarding structures. The current incentive structure has a negative impact on openness of both publications and data. Megan Carey, in "Funding and career advancement in an Open Science environment" (section 2.3), makes a deep analysis on why the widespread citation-driven funding scheme does not benefit Open Science practice, and why open data practices are not widely embraced by researchers who are forced by current conditions to think on an individual rather than a collective level. It is clear, then, that current system has to be revised by giving new and less bureaucratic criteria to fund excellent research, and a new Open Science Culture has to be built based more on "trust" than on "control", with greater integrity and rationality.

Open source is certainly an aspect of transparency. Open source refers primarily to the availability of original coding to be accessed, modified and repurposed, but granting access to source code is really equivalent to publishing your methodology when the kind of science you do involves numerical experiments. Without access to the source for the programmes we use, we rely on faith in the coding abilities of other people to carry out our numerical experiments. When simulation codes or parameter files are proprietary or are hidden by their owners, numerical experimentation isn't even science. A "secret" experimental design does not give sceptics the ability to repeat and verify your experiment, and the same is true with numerical experiments. Science has to be "verifiable in practice" as well as "verifiable in principle". In general, we are moving towards an era of greater transparency in all of these topics: methodology, data, communication, and collaboration.

Making the entire primary record of research project publicly available on line is an excellent tool to facilitate scientific collaboration. This practice is known as Open science notebook. The purpose is to allow immediate communication of scientific results.

2.2.4. STRENGTHEN DIALOGUE BETWEEN SCIENCE AND SOCIETY: SCIENCE WITH AND FOR SOCIETY

The health of a science and innovation system depends, among others, on the scientific vocations we are able to generate in the young; on the appreciation and support of the population, and on the sensitization of people working on it. By facilitating an effective dialogue between science innovation and society, Open Science has a direct influence in the improvement of European human resources dedicated to science and also in widening excellence. Moreover, the EU needs human beings capable of independent thinking, creativity, insight, and innovation, because every benefit in our society is a direct result of independent thinking, very often in the form of scientific activity.

Open Science contributes highly to making Europe a more attractive space for creativity, by establishing a particularly stimulating environment to making scientific breakthroughs. After all, the creation of new ideas is about seeing things differently, about breaking the rules, about sharing knowledge, and about being tolerant of errors already made. The readiness to listen to independent voices, to encourage risk-taking, to share results, and to foster a climate of mutual learning and trust are prerequisites to successfully establishing a true culture of creativity.

An effective dialogue between science innovation and society allows citizens to have enough knowledge to form opinions, give ideas, make contributions (crowdsourcing), and take rational and informed decisions on scientific and technical issues of social importance, and then, more fully participate in the democratic processes of an increasingly scientific and technological society (The Democratic Society, 2016). Then, Open Science certainly also contributes to make societies more democratic.

Horizon 2020 regulations include a specific objective: "Science with and for society," which aims to build effective cooperation between science and society, in order to recruit new talent for science and to pair scientific excellence with social awareness and responsibility. (Science with and for Society Advisory Group, 2016)

2.2.5. LINK SCIENTISTS TO SCIENCE POLICY MAKING

Scientists and science policy makers should be encouraged to work together. Science helps both to decide and develop the right policies and to evaluate them properly. Policy initiatives supported by research evidence – evidence-based policy making (MacArthur Foundation, 2014) – are likely to be more successful and policies introduced on a trial basis have to be evaluated to be addressed if necessary. Then, science is before and after; policy is the meat in the scientific sandwich (Choi et al., 2005)

Apparently scientists and policy makers are far from being able to work together. They claim to have different languages, mentalities and goals. A science more accessible, transparent, integral, reliable, collaborative, and closer to citizens (Open Science), could help to fill this gap and reciprocally, strengthening such cooperation will contribute to a better openness of science.

Initiatives such as setting up the EC "Scientific Advice Mechanism" (SAM) (EC, 2015a) with the aim to support the European Commission with high quality, timely and independent scientific advice for its policy-making activities, and the "Research, Innovation, and Science Policy Experts" (RISE) high level group (HLG) EC, 2015b) to give direct strategic support to the Commissioner for research, innovation, and science, Carlos Moedas, go also in that direction.

Global Systems Science (GSS) Sneider et al., 2002; Jaeger et al., 2013) was developed to provide scientific evidence to support policy-making, public action to engage in societal actions on globally interconnected challenges such as urbanism and migration, environmental issues and climate change, financial crises, or containment of pandemics. The ICT engines behind GSS are large-scale computing platforms to simulate highly interconnected systems including cross-cutting policy dependencies and interactions, data analytics for 'Big Data' to make full use of the abundance of data on social, economic, financial, and ecological systems available today, and new tools and processes for linking scientific evidence into the policy process and into the dialogue with society (Bishop et al., 2014).

2.2.6. DEVELOPING PROPER E-INFRASTRUCTURES, DIGITAL TOOLS, SERVICES, AND LEGAL AND POLICY REQUIREMENTS FOR OPEN SCIENCE

ICT tools are essential to progress on the way to Open Science. To make science more open, global, collaborative, creative and closer to society relies on the combined effects of technological development and cultural change.

In order to give support to open science, the European Commission has launched the "European Cloud Initiative – Building a competitive data and knowledge economy in Europe" (EC, 2016d,e). It will enable researchers, across borders and scientific disciplines, to process the huge amounts of scientific data generated by research and to share their scientific results while improving access to knowledge and thus, innovation. The initiative will bring supercomputing and data sharing to researchers, industry, SMEs and public authorities in Europe through a virtual environment for the storage, management, analysis and re-use of data related to their research. Due to an upcoming technology paradigm shift in HPC (the transition from petascale, to exascale) a window of opportunity is opening for Europe. One objective of the European Cloud initiative is to see a supercomputer based on EU technology among the world top three by 2022. The final objective is to give Europe leadership in the data-driven innovation, based on the capacity to process, manage and store the huge volumes of information generated by great amounts of data.

Open science makes also the R&I system and the scientific processes more efficient, transparent and effective by offering new tools for scientific collaboration, experiments and analysis and by making scientific knowledge more easily accessible. A series of tools and services scientists can use to open their science are listed in pages like (OKF, 2011), organized in different topics and covering different facets of Open Science. The Open Access Directory (OAD, 2008) is a compendium of useful and accurate information on Open Access to science maintained by the OA community. By bringing many OA-related lists together in one place, OAD makes it easier for everyone to discover them, and use them for reference. Tools for Open Access are part of the Open Access Directory.

Also, the Engaging the Research Community towards an Open Science Commons was launched by the EGI-Engage project (EGI, 2015), involving more than 70 institutions in over 30 countries, to accelerate the implementation of the Open Science Commons by expanding the capabilities of a European backbone of federated services for compute, storage, data, communication, knowledge and expertise, complementing community-specific capabilities. But Open Science challenges are not limited to those related to infrastructure and technology or research culture, they also include administrative, legal, and privacy regulations, and ethical, institutional and policy issues, mainly related to sharing and providing Open Access to research data and public sector information (PSI) from a variety of sources, and in a variety of formats. Open Access long-standing principles as those described by the Budapest Open Access Initiative (OAI), (Budapest, 2002) and in its 10-year update, (Budapest, 2012) include recommendations on public policy changes, licensing, privacy, intellectual property rights (IPR), scientific heritage, infrastructure support, and advocacy. They should be taken into consideration.

2.2.7. HUMAN RESOURCES: SKILLED PEOPLE FOR OPENNESS AND RESEARCH INTEGRITY

As OS methods and practices are increasingly taken up, the gaps in skills and in numbers of skilled people for Open Science are becoming more and more evident. Enhancing the skills, capabilities and knowledge of human resources is crucial for OS development and success. Open Science training programmes, such as "Facilitate Open Science Training for European Research" (FOSTER, 2014) are being promoted, especially for young researchers, to set in place sustainable mechanisms for EU researchers to foster Open Science in their daily workflow and adopting of EU open access policies.

As research usually takes place within an institutional framework, organizations themselves have to be prepared to make as easy as possible the transition towards an open research culture, suiting its services and human resources to accommodate an Open Science workflow, for that they have to organize their proper training programmes for developing or acquiring the appropriate skills. The OS training initiative (OSTI, 2013) is intended to be included in the formal curriculum to teach young scientists about Open Science while they are still young and learning about the scientific method. Students participating in the pilot project came out strongly in favour of receiving training in licensing and on development of the publication process: furthermore, they have shown that hands-on experience is the best way to learn about how to license (legal skills), how to release data (digital skills), and how to communicate science (communication skills) (University of Oxford, 2013).

Other training modalities include: the DIY Research Data Management Training Kit for Librarians (Macdonald and Rice, 2013)[17], designed to contain everything needed to complete a similar training course on your own and is based on open educational materials from the UK; while Measuring Your Research Impact (MyRI, 2011) is a series of online tutorials created by three Irish universities: Dublin City University, Maynooth University and University College Dublin.

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[17] *http://ceur-ws.org/Vol-1016/paper27.pdf*

Training programmes should be aligned with the EU principles on Responsible Research & Innovation (RRI). Ethics and research integrity have to be included in those programmes. Mary Ritter (section 2.6) defines Research Integrity as a *responsible conduct of researchers intrinsic to the values of research and the trust it engenders, and states: Science can only be open if it and its output data can be trusted, so Research Integrity there lies at the very foundations of open science*. Her report is an excellent overview on research integrity.

2.2.8. FINAL REMARKS

As key funders of public research, Member State governments, universities and research centres, and research councils should lead the Open Science process. Leadership of these organisations is necessary to succeed with OS, especially with this publishing and career evaluation paradigm shift. Scientists should be well informed about Open Access to recognize that it is perfectly viable, but pushing for those changes should be the job of the established, not the beginners.

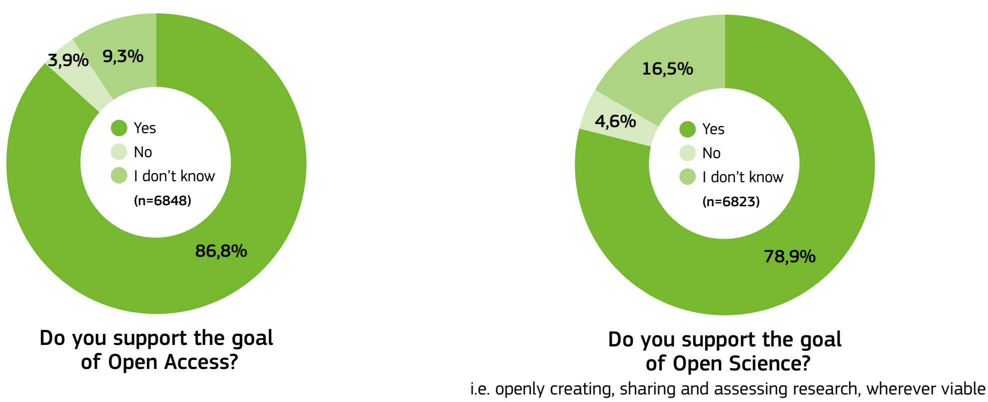
2.3 FUNDING AND CAREER ADVANCEMENT IN AN OPEN SCIENCE ENVIRONMENT[18]

Megan R. Carey

2.3.1. REMOVING BARRIERS TO OPEN SCIENCE

There is nearly universal support for Open Science within the scientific community (Fig OS.1). While encouraging, this raises an important question: if support for Open Science is so widespread, why are Open Science practices less so? One answer is that, while competition is good for stimulating and selecting excellence, warped incentive structures resulting from extreme competition for funding and career progression form a major barrier to Open Science. Current conditions for European research are, therefore, not conducive to Open Science.

Figure 0.1: Responses from EU researchers to survey questions on support for Open Access publication (left) and Open Science practice in general (right)



Source: See footnote[19].

[18] *This contribution is built on extensive discussions within the Open Science group, the broader RISE group, and with external specialists at the Mallorca Workshop (see the Mallorca Declaration on Open Science, Appendix 1 to this book). Overall, the view that emerged is that true progress on Open Science will require fundamental rethinking of how research is funded and researchers are rewarded. The data we quote is focussed particularly on that obtained from a survey of young European researchers in the field of neurosciences; while this does not necessarily reflect the views of researchers in other fields or different age profiles, it is important since it is the recruitment and retention of future generations of researchers that will be crucial if Europe is lead the world in Open Science.*

[19] *Data are from the Survey of scholarly communication tool usage. Figure is copied with permission from https://101innovations.wordpress.com/2016/04/04/support-for-open-science-in-eu-member-states/*

Policies such as the recent call to make all EU-funded publications Open Access (OA) by 2020, or requiring divulgation of data are a necessary first step towards making Open Science practice more widespread within Europe (see section 2.4. and 2.5.). However, the effectiveness of such strategies on their own is limited, for several important reasons. First, care must be taken to ensure that these policies do not create undue financial/administrative burdens on researchers. To this end, efforts to support these actions, such as making OA publishing costs grants-eligible and providing low-cost and efficient means of data storage and re-usage, are important.

Another critical limitation of directive-based strategies is that they cannot be aimed at researchers outside of the EU funding umbrella – but science itself is global. If researchers perceive that these requirements will negatively impact their global competitiveness, it could reduce the attractiveness of EU funding. Because we cannot mandate openness of research funded by private sources, or around the world, it is important to incentivize rather than simply mandate Open Science practices.

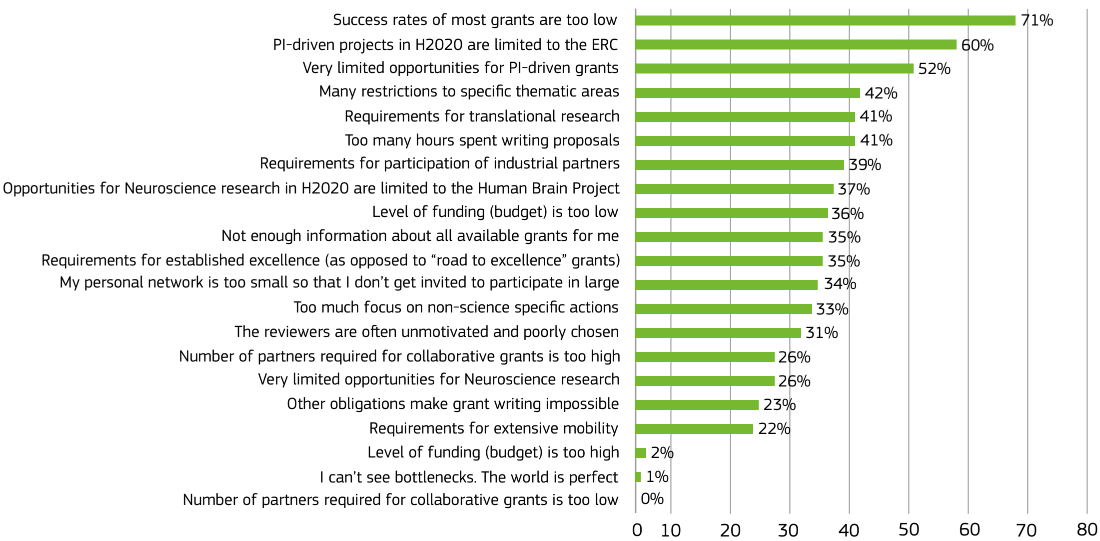
Here we analyse the current research culture and the unintended barriers it poses for widespread adoption of Open Science practice. We start with an overview of the current situation, with an emphasis on the view from researchers' perspectives (Section 2.3.2). In Section 2.3.3, we discuss how the current climate of extreme competition creates incentive structures that discourage openness. Finally, in Section 2.3.4 we present suggestions of actions that could be considered, in order to align European funding and career assessment with the goal of creating an Open Science culture.

True progress on Open Science in Europe will require rethinking the way research is funded and researchers are rewarded, in order to address the underlying forces that currently act to discourage Open Science. Long-term policy changes must directly address and remove the current barriers to Open Science practice. Such actions could fundamentally change research culture – simultaneously improving conditions for researchers, promoting excellence, and encouraging openness.

2.3.2. EXTREME COMPETITION FOR LIMITED RESOURCES IS A BARRIER TO OPENNESS

The availability of stable, long-term research positions and grant funding is not keeping up with the growing number of excellent highly trained PhDs, postdocs, and investigators. There is increasingly intense competition at nearly every career stage. This creates an incentive structure that is not truly conducive to doing the best possible science, nor to

Figure OS.2: Responses to funding survey: Funding obstacles



Source: A survey conducted by the FENS Kavli Network of Excellence, 2016. Data represent responses from 310 early-career (87% independent less than 10 years) neuroscience PIs based in 24 European countries. Researchers identified low success rates and limited opportunities for PI-driven grants as the most significant obstacles to funding their work (red rectangle).

doing it openly. It can encourage secrecy at best, and tempt a loss of research integrity at worst. Here we focus on two particularly problematic aspects of the current European research funding environment: low grant success rates and a need for more Principal Investigator (PI)-driven funding opportunities. These factors were immediately recognized as critical barriers to Open Science by the RISE Open Science Group and were independently identified by the external experts at the RISE Open Science Workshop, Mallorca, May 2016, as well as the respondents to a Funding Survey conducted by the FENS Kavli Network of Excellence, 2016 (Figure OS.2).

Low funding success rates

The current reality is that success rates are much lower than justified by the quality of applications. Within the EU, funding cut-offs routinely fall below the number of applications recommended for funding by expert review panels. The overall success rate for eligible proposals in the first 100 calls of H2020 was 14 % – down from 20 % overall in FP7[20]. We do not argue that competition itself is bad for science, but funding rates below 20-30% are problematic for several reasons. First, it has been repeatedly demonstrated that it is nearly impossible to discriminate meaningful differences in quality within that range. When variability in reviewer scores is larger than any actual differences in quality, selection processes lead to random outcomes, as evidenced by the experiment conducted by the organizers of the NIPS conference[21] in which conference abstracts were evaluated by two separate review panels. Further, a recent analysis of US NIH peer review assessment found that NIH peer review percentile scores were poorly predictive of grant productivity when funding levels were similarly low (Fang, Bowen and Casadevall, 2016).

In this context it becomes clear that extremely low success rates do not reflect a paucity of exceptional applications, but rather, a failure to identify and support the best research and researchers. It is essential to bring funding success rates back into a regime where Europe's best researchers can expect to attract and maintain funding for their best work. Solutions to this problem cannot rely solely on increasing apparent success rates through strategies that aim to reduce the number of applications. Rather, there is a need for better ways to identify and support the very best researchers and ideas, and give them the conditions they need to conduct open science (see also the San Francisco Declaration on Research Assessment[22]).

Faced with extremely low success rates, researchers are forced to prepare and submit more applications to fund their work. Researchers spend weeks and months preparing a single grant application. Submitting multiple applications for one successful round of funding translates into the loss of many months of research activity and productivity. Similarly, the abundance of applications increases the burden on the evaluation side, both for administrators and also in terms of time that researchers spend in peer review of each other's proposals.

In some cases the joint problems of low success rates and administrative burden have been addressed by establishing restrictions on who can apply for grants, for instance based on scores received in previous calls. At first glance this, as well as the possibility that low success rates may deter researchers from applying, may appear beneficial in that lower numbers of applications will increase success rates. However, given the elements of randomness in the selection process discussed above, it is difficult if not impossible to establish exclusion criteria that avoid excluding top candidates from the competition. Further, decreasing the size of the applicant pool can have the unintended consequence of also decreasing its overall quality. Self-selection may not affect all researchers equally. Researchers that perceive that they have a lower chance of funding – whether because they are part of underrepresented groups, or because they are coming from outside of the current scientific establishment, or because of the Dunning-Kruger effect (a cognitive bias in which less competent people overestimate their abilities and more competent people underestimate them)[23] – will be disproportionately affected. Solutions must be sought that improve success rates while keeping the quality of the applicant pool as high as possible so that the very best work is funded.

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20) See DG RTD, EC (2015). Horizon 2020: First Results. https://ec.europa.eu/programmes/horizon2020/sites/horizon2020/files/horizon_2020_first_results.pdf

21) http://blog.mrtz.org/2014/12/15/the-nips-experiment.html

22) http://www.ascb.org/dora/

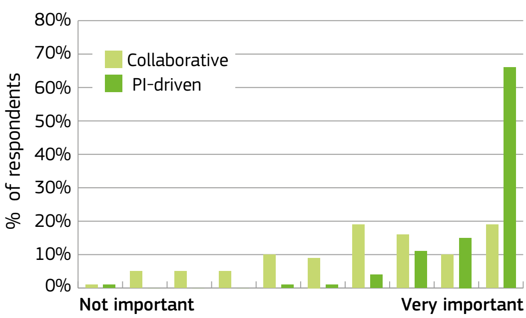
23) See Kruger and Dunning (1999).

Need for PI-driven funding opportunities

After low success rates, the most often-cited obstacle to obtaining funding reported by FENS Kavli survey respondents was a relative lack of PI-driven funding opportunities (Fig. 2). While 46% of survey participants rated collaborative grants as ≥8/10 in importance for funding their work, fully double that number – 92% – rated PI-driven grants similarly highly (Fig. OS.3). Further, more than three times as many respondents rated PI-driven grants as maximally important (10/10) as compared to collaborative grants. The RISE Open Science Group and the participants in the RISE Open Science Workshop in Mallorca[24] similarly identified a critical need to increase PI-driven funding opportunities.

PI-driven projects form the backbone of most researchers' research programs. Compared to large-scale collaborative grants, PI-driven funding mechanisms have the advantage of allowing flexibility to respond and adapt to current, cutting-edge ideas and technologies. Moreover, larger collaborative projects are less accessible to researchers outside of established communities. The comparatively large administrative burden of preparing these proposals is often most effectively navigated by well-established researchers and institutions. At the same time, the larger networks required to form successful proposals make it difficult for those outside of the current establishment to crack into the system.

Figure OS.3: Responses to funding survey: collaborative vs. PI-driven grants



Source: Funding Survey conducted by the FENS Kavli Network of Excellence, 2016. Data represent responses from 310 early career neuroscience PIs based in 24 European countries. Two-thirds (66%) of researchers rated PI-driven grants as being of maximal importance for their work.

[24] *See appendix 1.*

2.3.3. CURRENT INCENTIVE STRUCTURES CREATE BARRIERS TO OPEN SCIENCE

The extreme competition for limited resources brought about in part from low funding success rates and limited PI-driven funding opportunities creates an incentive structure that has a direct negative impact on Open Science at the levels of publication, data, and integrity. This is exacerbated by an emphasis on evaluation metrics. For example, in many cases journal impact factor has become a proxy for the real quality or impact of a study.

Barriers to Open Access publication

In order to stay competitive within the current system, researchers plan their publication strategies to optimize their chances of obtaining future funding. Some systems reward researchers for publishing as many papers as possible. In this environment, researchers churn out large numbers of small studies, representing only minor, incremental advances. More often, however, there is overwhelming pressure to publish high-profile papers in order to compete for the largest, most prestigious grants. Researchers focus on putting together exciting "stories" that will attract the attention of the editors of the high-impact, for-profit, subscription journals. While this strategy can lead to funding success, it also has the consequence of encouraging researchers to pursue lines of research that are trendy, rather than doing the best possible science for the advancement of knowledge. Moreover, the pressure to put together an attractive story also challenges Research Integrity if it leads to data selection – or worse, outright fraud (see section 2.6.). It also places no premium on the open access status of publication, and it can greatly delay the divulgation of important results to the broader scientific community.

Barriers to Open Data

The benefits of Open Data for the scientific community as a whole are clear (McKiernan et al., 2016). It speeds discovery and provides important checks for reproducibility and research integrity. However, open data practices are not widely embraced by researchers, who are forced by current conditions to think on an individual, rather than a collective level.

A recent editorial in the New England Journal of Medicine argued against open data sharing, referring to the perceived threat of "research parasites," who could essentially build careers by jumping on data collected by others, reanalysing it and publishing without the involvement of the original authors (Longo and Drazen, 2016). Such arguments, while controversial, stem from the fact that resources required to collect data – in terms of funding and labour investment, can be enormous. When the data collected represents the only competitive edge a group has there is a natural desire to want to keep it. In an environment where availability and continuity of resources are highly uncertain, a system in which the researchers who manage to complete experimental studies are forced to openly share their data without reuse restrictions can be seen as threatening. Thus the potential costs of data sharing go beyond the actual expense and effort associated with storing data in an accessible way. Mandating Open Data without removing the underlying incentives for secrecy is unsustainable and may lead to undesirable effects such as funding opportunities with such requirements becoming less attractive for researchers. Long-term solutions will require not just mandating open access to data, but ensuring that the conditions exist to support experimental scientists to perform high-quality studies and enable them to share their data openly without the threat of losing their perceived competitive edge (see also section 2.5.).

Barriers to Open Science are most acute for Early Career Researchers

In today's competitive climate there is a hierarchy that has important implications for how to best build an Open Science movement. The researchers at the top of the hierarchy, in well-funded, stable conditions, can maintain cutting-edge research programs and can afford to diversify their work to ensure continued success and competitiveness. They have comparatively little to lose from practicing Open Science, and should be encouraged to lead by example. On the other hand, researchers in unstable conditions with uncertain futures face the strongest pressure to be the least open. Early career researchers are particularly vulnerable, as early successes can lead to improved conditions and enhanced productivity, thereby increasing likelihood of future success as well. With such a positive feedback loop in place, early career researchers face the most pressure to remain closed, and they cannot afford to take unnecessary risks. Yet ultimately, closed science inhibits mobility and keeps the less privileged out of the inner circle of knowledge. Therefore, it is particularly important to remove barriers to Open Science for early career researchers.

2.3.4. CHANGES FOR CONSIDERATION IN FUNDING TO PROMOTE OPEN SCIENCE

The RISE Open Science Group has identified several points that we believe could be actionable at the European Commission level to encourage Open Science practice by removing barriers imposed by the current incentive system.

More PI-driven funding opportunities

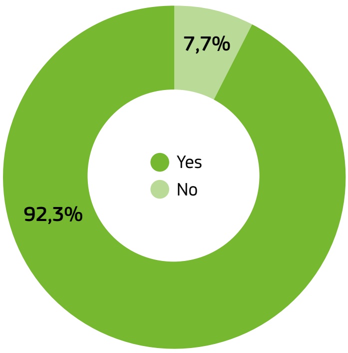
1. The findings in this chapter indicate the need to increase PI-driven funding opportunities for early stage researchers. Competitive, PI-driven funding mechanisms are uniquely able to allow the best researchers to pursue their most creative ideas and keep up with conceptual and technological innovation. PI-driven funding provides flexibility for scientists to engage in projects that they believe in, rather than those that they perceive as providing the strongest competitive edge. To minimize or neutralize additional costs the following could be considered:

    - A relative shift of funds away from large-scale collaborative projects towards PI-driven funding schemes. This idea has strong support within parts of the scientific community (see, for example, Fig. OS.4). Collaboration in general and specifically international collaboration is an important element of the research process, but there is a need to find better ways to encourage natural collaborations rather than mandating collaboration as a prerequisite to funding. A widespread adoption of Open Science practice will be a positive force in enhancing the collaborative nature of research.

- Because of the proven difficulty in predicting which projects will be successful, it is critical to support as many highly qualified researchers as possible, particularly early in their careers. To address this, fund allocation could be adjusted so that all applications that meet evaluation criteria and are considered fundable receive some funding, even if the total awarded for some or all grants needs to be reduced relative to their originally proposed budgets.

2. More generally, the granting schemes should undergo an overall simplification. Researchers find it difficult to navigate the complex web of European funding mechanisms (Fig. OS.5). Funding schemes should build on the most successful programs, such as the highly regarded ERC.

Figure OS.4: Responses to funding survey

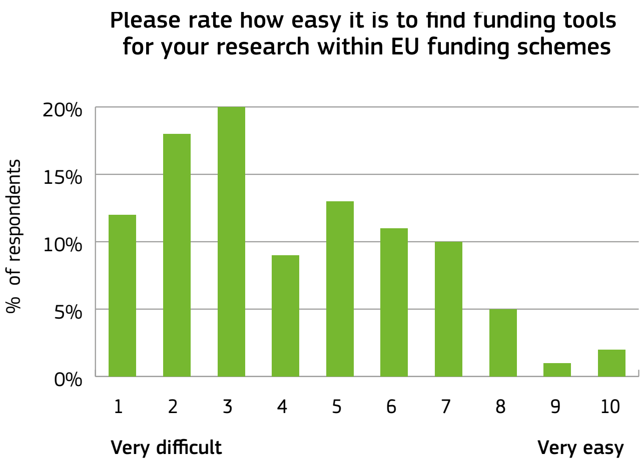


"The current grant funding budget is skewed towards big multi-investigator collaborations. Such grants favour experienced PIs over early career Pis with smaller networks. I would therefore welcome a change in the distribution of funds towards more single PL grangts to strengthen early career science in Europe." Do you agree with this statement?

(310 responses)

Source: Funding survey conducted by the FENS Kavli Network of Excellence, 2016. Data represent responses from 310 early-career neuroscience PIs based in 24 European countries. Researchers overwhelmingly support a redistribution of funding towards more single PI grants.

Figure OS.5: Responses to funding survey: funding schemes



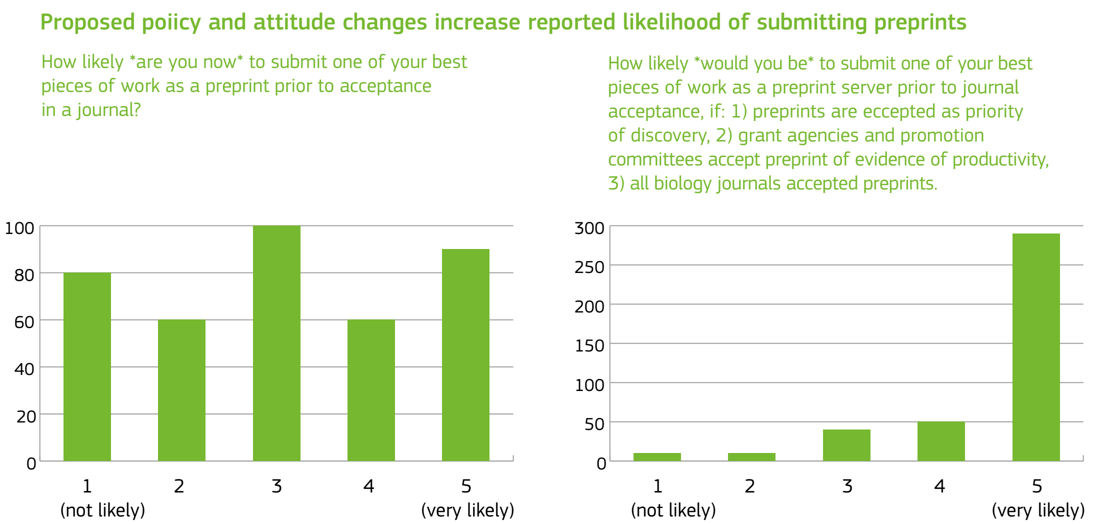
Source: Funding Survey conducted by the FENS Kavli Network of Excellence, 2016. Data represent responses from 310 early-career neuroscience PIs based in 24 European countries. Half (50%) of researchers reported that it was very difficult (≤ 3 on scale 1-10) to find funding tools within EU funding schemes.

Ultimately, there is a need to support a move towards funding centred on "people, not projects," the approach of several world leading funding organizations. The funding provided by, for example, the Howard Hughes Medical Institute, Wellcome Trust, or the Max Planck Society allows the world's top researchers the flexibility to take risks that the majority of researchers, constantly searching for their next funding opportunity, cannot. Given the difficulty in predicting which projects will be successful, it may be productive to alternatively focus on identifying researchers with exceptional track records who are likely to continue to succeed.

Meaningful changes to application and assessment practices

The RISE Open Science Group strongly endorses the use of the Green Open Access/ self-archiving model (for more detail see the following section 2.4.) as the most immediate solution for Open Access publication. While preprint servers like arXiv are already widely used within the physical and mathematical sciences, similar practice has yet to become commonplace within biology. A recent survey of biologists conducted by ASAPbio revealed that researchers would be significantly more likely to make use of preprints if grant agencies and promotion committees accepted preprints as evidence of productivity (Fig. OS.6). The European Commission should therefore instruct reviewers and review panels for all EC-funded grants to accept preprints as evidence of productivity in grant applications and reports. Assessment criteria should also explicitly and directly reward open access publishing, data sharing, and open resource development.

Figure OS.6: Opinions on preprints in biology



Source: Results from an online survey[25] with 392 respondents. Researchers would be significantly more likely to submit their work to an open access preprint server if grant agencies and journals accepted preprints as evidence of productivity/ priority of discovery.[26]

[25)] *See asapbio.org*

[26)] *Figure is copied with permission from http://asapbio.org/wp-content/uploads/2016/02/Preprint-opinions-graphic.jpg*

The use of evaluation metrics such as number of publications and journal impact factors should not be allowed to substitute for meaningful assessments of the content and quality of an individual's scientific output. To ensure that applicants for EU funding are evaluated properly, we recommend the following for consideration:

- Allowing candidates to highlight their major scientific contributions, by creating their own narratives. This may also include the use of letters of recommendation from respected colleagues. Note, however, that this change must be accompanied by training of reviewers in order to ensure that moving away from a metric-based system does not exacerbate implicit bias in the selection process.

- Ensuring that applications are reviewed by the most highly qualified experts possible. This may require additional members on evaluation panels, with expertise to cover more subdisciplines, as well as more remote evaluators per proposal. Furthermore, pre-registration as a requirement for becoming a reviewer should be removed, as this creates an undesirable barrier to obtaining input from the most highly qualified experts.

- Evaluating content and quality rather than metrics requires more time and effort from reviewers. To compensate for this and reduce the burden of grant preparation and evaluation, we recommend the general adoption of a two-stage application process. The Human Frontiers Science Program, for example, first evaluates short pre-applications and then invites longer proposals from a subset of candidates. This differs from the ERC, which has a two-stage review process, but a single-stage application process, meaning that in each call, thousands of pages of proposals are written that never get seen by evaluators.

- Other funding agencies, including the US National Science Foundation, have found that eliminating application deadlines decreases the number of grant proposals received[27]. The European Commission should therefore consider eliminating grant deadlines as a possible way to reduce the number of submissions without discouraging proposals from top candidates.

- Finally, it is crucial to align Open Science policies at the EU, Member States, and University levels. Given the attractiveness of EU funding not only for researchers but also for universities and research institutes throughout Europe, changes in assessment practices at the EU-level will propagate through Member State funding agencies as well as institutional hiring/promotion committees. Starting with the ERC may be an effective strategy, as it would directly impact Early Career researchers and its standards are widely respected as a badge of excellence. Changes should be implemented in partnership with highly respected international funding organizations, many of whom have experience with these approaches, thereby creating a unified model for Member States and Universities to follow.

2.3.5. EUROPE HAS AN OPPORTUNITY TO LEAD THE WAY ON OPEN SCIENCE

The analysis presented so far has focused on barriers to Open Science practice, particularly within Europe. Ultimately, however, the possibility of addressing and removing these barriers represents a tremendous opportunity for Europe. Realigning European funding with the goals of an Open Science culture will not only encourage Open Science practice within Europe, it will also improve research conditions and enhance Europe's attractiveness for top researchers. This is a chance for Europe to lead a global shift towards Open Science culture that promises to positively impact the acceleration of discovery and innovation worldwide.

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[27] *http://www.sciencemag.org/news/2016/04/no-pressure-nsf-test-finds-eliminating-deadlines-halves-number-grant-proposals*

2.4 SCHOLARLY PUBLISHING AND PEER-REVIEWING IN OPEN ACCESS[28]

Marie Farge

2.4.1. INTRODUCTION

Knowledge, like language, is not a merchandise to be traded; it is the knowledge commons[29] that everyone, everywhere, can share and which is preserved for generations to come. Indeed, when a researcher gives an idea to a colleague, she does not lose it. Quite on the contrary, she wins someone with whom she can exchange, and make her idea evolve, in clarifying it, modifying it if necessary and finding applications she did not think of. An idea that is not shared nor preserved is lost forever. The positive-sum exchange of ideas and viewpoints lies at the heart of peer review, whose purpose is to verify, correct and improve the content of scholarly articles before disseminating them. It would, indeed, be damaging for knowledge and research if errors are circulated and reused assuming they are exact.

Peer reviewing articles written by colleagues is an integral part of a researcher's duty, together with giving seminars and writing articles. This is why researchers, in most cases, do not request any extra payment or advantages to referee an article or to be a member of the editorial board of a peer-reviewed journal. Peer reviewing should deserve more recognition (e.g. for career evaluation) because, if done seriously, it is time consuming, requires a highly specialised expertise and sustained attention to details. Peer reviewing is the backbone of the present research system since it guarantees the quality and the originality of the articles published in scholarly journals of all disciplines.

Publicly funded research is financed by taxes that everybody pays, therefore articles presenting the results obtained in this context should belong to everybody (as for knowledge commons) or not belong to anybody (as for the public domain). In practice, this means that they should be accessible for free the moment they are published. Unfortunately, this is far from being the default case at present. Today, when an article succeeds to pass peer review and is accepted for publication by the journal's editorial board, its authors are required to give without compensation their copyrights to the journal's publisher. The publisher therefore owns the text, figures, codes and data presented in the article, and those deposited on the journal's website, until seventy years after the author's death. If the author refuses to give her copyrights away, her article is not published[30]. Thus publishers can sell back scholarly articles to academic libraries, at prices they fix themselves, during more than one hundred years. Hence, most research articles of the 20th century remain locked behind pay-walls. Obviously, the goal of all this is not to ensure an optimal dialogue among researchers; it certainly is not to ensure intellectual property rights for the creators of new knowledge; it is simply to ensure property rights to publishing firms. Some of them manage, through a profit-making conceit, to trump the importance of knowledge creation with a relentless quest for increased revenues.

Because of the transfer of intellectual property rights, publishers can decide under what conditions and at what prices, the research results in the form of articles can now be accessed, exploited, and re-used. Since a few years, the objective of publishers is to link articles to databases. When this will be achieved, transferring the copyrights to publishers will also give them rights on research data (e.g. measures, satellite images, results of numerical simulations, source codes, and more...). This will open the way to transforming data into merchandise, which will be counter-productive for research and contrary to the academic tradition of data sharing. Data are an integral part of knowledge and, like ideas, must be of free use. Therefore data must stay outside the market to preserve the collaboration between researchers that relies on free and multilateral exchange (Ian Mulvany considers the challenges facing Open Data in section 2.5 of this Open Science chapter). The risk is that publishers interfere with this process to take advantage of data and increase their profits at the expense of researchers and taxpayers.

In this section the definition of open access published by the European Commission in 2010[31] will be used: *'Open access, a model which provides access, use and*

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28) *A website complements this chapter. See http://openscience.ens.fr*

29) *Hess, C. and E. Ostrom (2006).*

30) *See examples of copyright transfer forms at http://openscience.ens.fr/COPYRIGHTS_AND_LICENSES/*

31) *http://openscience.ens.fr/DECLARATIONS/2012_07_17_European_Commission_Towards_better_access_to_scientific_information.pdf*

re-use free of cost to readers on the Internet. Two basic models exist: "Gold" open access (open access publishing): payment of publication costs is shifted from readers (via subscriptions) to authors. These costs are usually borne by the university or research institute to which the researcher is affiliated, or by the funding agency supporting the research. "Green" open access (self-archiving): the published article or the final peer-reviewed manuscript is archived by the researcher in an online repository before, after or alongside its publication. Access to this article is often delayed ("embargo period") at the request of the publisher so that subscribers retain an added benefit'.

Note also that, when one writes 'publishers', only the major ones are meant, namely a few commercial companies or not-for-profit societies which dominate and control the market. Since the advent of electronic publishing they have acquired an oligopolistic position by competing with smaller publishers that they swallow or push out of the market. When one writes 'articles', only peer-reviewed articles written by researchers to present their results to other specialists of the same discipline are considered. By 'researchers' one means scholars employed by universities or research institutions whose research activity is fully, or partially, funded by public institutions. The arguments developed here are made from the point of view of a researcher who peer reviews (as editor and referee) and publishes in international journals of mathematics and physics. Therefore, some arguments might be specific to these disciplines since practices significantly vary depending on the discipline and scale (national or international) of the scholarly exchanges. The questions addressed here will only concern the data linked to peer-reviewed articles (for referees and readers to verify the article's content).

2.4.2. RESEARCHERS SHOULD OWN THE PEER-REVIEWED JOURNALS THEY CREATE

Today the large majority of peer-reviewed articles are still published with the toll access model, where institutions pay a subscription to publishers in order that their researchers can read scholarly journals. However, the few publishers who dominate the market are imposing the *gold open access* model where, in order to publish, authors or their institutions have to pay *article processing charges*, whose amount is fixed by the journal's publisher. The 'Hybrid model', which is presently the usual way for publishers to propose *open access*, is an even better deal for them, since in this case both readers and authors must pay subscriptions and *article processing charges*.

In 2012 Sir Tim Gowers, professor at Cambridge University, and thirty-three mathematicians from all over the world launched the movement "The Cost of Knowledge" and called to boycott Elsevier[32]. They denounced Elsevier's lobbying for the *Research Works Act*, a bill proposed to the American Congress aimed at prohibiting *open access* mandates for federally funded research and thus reversing the policy of the National Institute of Health (NIH), which requires taxpayer-funded research to be freely accessible online. The mathematicians of "*The Cost of Knowledge*" considered it was also their duty to design alternative publishing models to recover control of the peer-reviewed journals they create and use. In June 2012, they proposed the *diamond open access* model (a terminology inspired from the *Diamond Sutra*, a treasure of the British Library that was printed in 868 in China). This model assumes that researchers should not pay to publish their articles, and should own the journals they create and peer review. The *diamond open access* model[33] is based on three principles:

- the authors keep their copyrights and attach to their article a *Creative Commons* license CC-BY[34] (requiring only the attribution of the paper to its authors, while allowing everyone to publish their article, together with any derivative products such as a translation, and even to earn money for doing so);
- the editorial board is the legal entity which owns the journal (i.e., its title and all its assets), whose members are active researchers (i.e., peers) who take responsibility of peer reviewing, that they perform without being paid (since it is part of their academic duty for which they receive a salary);
- the publisher is no longer the journal's owner but becomes a service provider under contract with the editorial board, whose members can thus choose the publisher they prefer, or look for another one if they are not satisfied by the delivered services.

32) http://thecostofknowledge.com/

33) See http://openscience.ens.fr/OPEN_ACCES_MODELS/DIAMOND_OPEN_ACCESS/ for further details.

34) https://creativecommons.org/share-your-work/

There already exist many journals which are published in *diamond open* access for which authors or their institutions do not have to pay *article processing charges*, such as IPOL (*Image Processing On Line*)[35]. In order to limit the journal's cost, the peer reviewing and publishing processes are automated using appropriate software, as commercial publishers do for the journals they own. But there is an essential difference between this and the full diamond open access model, since the software used to help editors for peer reviewing and publishing their journal are *free open source* software developed by the community of researchers to match their needs, such as OJS (Open Journal System)[36] developed by John Willinsky at Stanford University and PKP (Public Knowledge Project).[37]

In contrast to the proprietary software designed by publishers for their own sake, free open source software allows researchers (acting as authors, referees and editors) to make sure they cannot be spied on by publishers willing to automate the peer reviewing process. For some major companies this has unfortunately become one of their practices to improve the journal's productivity (i.e., more articles per issue and less time reserved for peer reviewing) rather than its quality. For instance, on August 13th 2016, the US Patent Office granted to Elsevier a patent entitled "Online peer review and method".[38] Indeed, commercial publishers have first to satisfy their shareholders who consider academic journals as very profitable commodities, without caring about the intellectual value of peer reviewing since they do not pay for it. Unfortunately, some academic publishers, although they are not-for-profit societies, have adopted the same practices to counteract the fierce competition of major commercial publishers and try to remain in the scholarly publication market.

Another way to publish in diamond open access is to rely on the open repositories developed for green open access. This leads to the concept of overlay journals (also called epi journals), where authors first deposit their article in an open repository to be peer reviewed. The authors have then two possibilities, either they mention the journal where they would like to submit their article, or they let different editorial boards find their article (since it is already in open access) and propose them to peer review it. An overlay journal is simply a set of links to the articles which have been peer reviewed and accepted by its editorial board (e.g., Discrete Analysis[39] whose articles are in the open repository arXiv[40] and which manages the peer-review process with the software scholastica[41]). The prestige of journal should only depend on the expertise of the members of its editorial board and the quality of the peer-reviewing process they perform. The journal impact factor is a nonsensical bibliometric indicator, gamed by publishers but actually counter-productive for research assessment, as shown by DORA (San Francisco Declaration on Research Assessment[42]). The journal impact factor should be abandoned and replaced by author-based or article-based criteria (e.g., article-level metrics ALM or altmetrics). Since all documents deposited in an open repository can be copied for free, it guarantees that the most interesting and most useful articles (together with their data and codes if they are deposited too) will always remain available. The number of such copies is certainly a much better bibliometric indicator for the value of an article than the *journal impact factor.*

When alternative open access models will have proven to be effective (i.e., for the quality of articles they publish, the efficiency of their dissemination and financial viability), editorial boards might be able to emancipate existing journals. Indeed it might be necessary for a community of researchers to take back control of the best, and often the oldest, journals they use to publish their results. Emancipating a journal means that its intellectual property is transferred from the publisher to the editorial board, the publisher being then paid as service provider and no more the owner of the journal's title, as proposed in 2012 by IMU (the International Mathematical Union[43]). Such a negotiation is complex and requires good lawyers to help the

35) *http://www.ipol.im/*

36) *https://pkp.sfu.ca/ojs/*

37) *https://pkp.sfu.ca/*

38) *http://openscience.ens.fr/OTHER/PUBLISHERS/ELSEVIER/ELSEVIER_PATENT_ON_PEERREVIEWING/*

39) *http://discreteanalysisjournal.com/*

40) *https://arxiv.org/*

41) *https://scholasticahq.com/*

42) *http:///www.ascb.org/dora/*

43) *http://openscience.ens.fr/ABOUT_OPEN_ACCESS/BLOGS/2012_10_22_Ingrid_Daubechies.pdf*

editorial board to recover control of the journal, arguing that its reputation is based on the quality of the peer reviewing of its editorial board, rather than on the quality of the type-setting and printing of its publisher. Emancipating a journal is preferable to creating a new one. Indeed, if an editorial board resigns and creates a new journal, the publisher keeps the title of the original one and has only to ask other researchers to form a new editorial board. The new journal then has a different title and competes with the original journal. Although the chances of survival are quite low for the new journal, some have succeeded to do so (e.g., in December 2006 the editorial board of "Topology" published by Elsevier resigned and launched the "Journal of Topology", which has been published since 2007 by Oxford *University Press*, and in 2009 Elsevier had to stop the publication of "Topology"). There are quite a few journals, from a very wide range of disciplines, which have managed since 1989 to become emancipated from their publisher and to launch a new journal.[44]

The following actions should therefore be considered:

- *Green open access* model *with an open access button*. The Green open access model (where one of the authors of an article deposits the author's version in an open repository) is the best solution to guarantee a smooth transition from toll access to open access, while leaving room for innovation and fair competition to design new alternative models. The European Commission could facilitate, and eventually support, the development of a variety of open repositories of different sizes, offering new services for researchers (e.g., Zenodo[45], the open repository of OpenAIRE[46] which is supported by the European Commission). Many solutions should be tested before selecting the most appropriate ones. To ensure that all peer-reviewed articles be available in open access as soon as they are published, open repositories should provide an open access button which automatically sends an email to the author of an article retained under a publisher's embargo, asking her to send her author's version to a reader looking for her article.

- *Recognition of preprints as evidence of productivity in proposal evaluation*. For evaluating a proposal the European programmes (e.g., Horizon 2020) or the European institutions (e.g., the European Research Council, ERC) should take into account not only articles which have been published, but also those under peer review, for which a version has already been made public by depositing it in an open repository. For anteriority an article thus freely available in an open repository should be considered to be as relevant as its version published in toll access or *gold open access*. Indeed, the preprint made accessible on an open repository before the peer review has been completed should be recognized as the first report of a new result.

- *Transparency of ownership, processes and cost of publishing*. Projects could be established, supported by the European Commission, to describe and clarify the overall scholarly publishing process. This should include: description and analysis of the ownership of all assets (i.e., articles, journal title, peer review documents, editorial platform, journal's website, metadata, bibliometric data, download data), and how these practices vary between the various disciplines. Links to the best tools describing the current publishing system and estimating its overall costs could also be provided. The aim would be to recommend good practices and detect bad ones.

- *Legal support to researchers, librarians and funding agencies*. Legal support could be provided, for example by the European Commission, to analyse the ownership of scholarly journals, articles, supplementary data that authors deposit on the journal's website, articles' metadata, peer review reports and mails exchanged via the journal's editorial platform, the data harvested during peer reviewing and during articles' downloading. It is important to analyse the legal framework for hiring editors, transferring copyrights, subscribing, paying article processing charge, creating and selling scholarly journals. Legal support to researchers who wish to create new journals, or take over existing ones could also be offered.

- *Modification of the European law*. When articles have been peer reviewed (by researchers not paid by publishers) and accepted for publication, most publishers require that authors give them exclusive rights on their work. Contracts concluded by publishers based on such rights are not disclosed, since they are

[44] *See http://oad.simmons.edu/oadwiki/Journal_declarations_of_independence*

[45] *http://zenodo.org*

[46] *https://www.openaire.eu/*

subject to the exemption provided by the European directive 93/37/CEE. There are two main issues: an imbalance between researchers and publishers and a lack of transparency and competition. The European Commission could then propose to declare clauses that grant exclusive rights to publishers unfair and without effect, and to force publishers to disclose these contracts. Furthermore, and consequently to Brexit, the European Commission could reconsider the present negotiation about European copyright law. Indeed, besides the United Kingdom, other Commonwealth members and United States of America which are ruled by copyright, most of United Nations members are ruled by author's law. Europe could then play a leading role to promote author's law, to give a better protection to authors and a legal status to *knowledge commons*.

2.4.3. RESEARCHERS NEED PUBLICLY-OWNED AND OPEN SOURCE PUBLISHING PLATFORMS

There already exists all over the world a very large number of institutional or disciplinary open repositories, registered in DOAR (the Directory of Open Access Repositories[47]), where researchers can deposit a version of their articles, before or after their publication. Depositing articles on a repository may be voluntary or may be requested by authors' institutions or granting agencies. The choice of the version depends on how authors have given their copyrights to the publishers (see examples of the copyright transfer form they have to sign in order their article be published[48]). Unfortunately, many institutional or disciplinary open repositories do not match the appropriate standards for curating metadata and therefore remain hidden to search engines. Moreover, even if someone finds the article she is looking for, she often cannot download its full text and has only access to its metadata (i.e., title, names and institutions of its authors, abstract). This is due to the embargo period most publishers impose. Several countries are presently modifying their legislation to limit such embargo periods to a minimum, or even to forbid them. For instance, France has voted and adopted a new law, called "Loi n°2016-1321 du 7 octobre 2016 pour une Republique numérique", which limits the embargo period to six months for articles concerning science, techniques and medicine, and to twelve months for those in humanities and social sciences.[49] It is always possible to overcome the publisher's embargo by providing an open access button (also called *request eprint* or *Harnad's button*) which, if an article is still under embargo, automatically sends an email to its authors asking them to kindly provide the full text of their article.[50] Thanks to such an *open access button,* we have now the *immediate green open access* model which complies with the policy of Carlos Moedas (the European Commissioner for Research, Innovation and Science) to have full open access to all scientific publications by 2020 and which was accepted on May 27th 2016 by the Council of the European Union[51].

Many publishers currently use electronic platforms to reduce the cost for peer reviewing and publishing their journals. By automating most of the process, they no longer need to provide a secretary to help the editorial board. For instance, Elsevier has developed the electronic platform EVISE[52] (which replaces EES, Elsevier Editorial System) to handle the peer reviewing of all its journals, whatever their discipline, and requires that authors, editors and referees use it. As a result, the whole peer reviewing process of journals is under the control of publishers that own all documents produced by the editorial boards using their editorial platform. This was not the case when peer reviewing was done using email, since editors were then exchanging private mails with authors and referees. What is wrong with this present evolution is that authors, editors and referees have to use the editorial platforms designed by publishers to reduce their costs rather than improve the quality of peer reviewing. A much better solution would be that the editorial platforms be designed by researchers, with the help of software developers, in order to facilitate their task and give them the control of what the platform is actually doing. It is important to use *free open source software*, in order to know which data

47) *http://www.opendoar.org/*

48) *http://openscience.ens.fr/COPYRIGHTS_AND_LICENSES/COPYRIGHTS/COPYRIGHT_TRANSFER_FORMS/*

49) *http://openscience.ens.fr/LAWS/FRANCE/2015-2016_LOI_POUR_UNE_REPUBLIQUE_NUMERIQUE/*

50) *https://openaccessbutton.org/*

51) *See the point 12 of the Council conclusions on the transition towards an open science system in http://openscience.ens.fr/DECLARATIONS_ON_OPEN_ACCESS/2016_05_27_European_Union_Council_on_the_Transition_towards_Open_Science.pdf*

52) *https://www.elsevier.com/editors/evise*

are harvested doing the peer reviewing process and to share expertise between different editorial boards. This will lead to collaborative development of new innovative methods of peer reviewing, editing and publishing, while converging together towards good practices.

A new component of the system we propose is the establishment of publicly owned and publicly funded publishing platforms, which would be designed to peer review and publish a very large number of journals from different disciplines and to help researchers to freely disseminate their articles. These would publish at no cost *diamond open access* journals that are recognised as being useful to their disciplines and whose editorial boards demonstrate that they are carrying out good peer reviewing practices. The accepted articles would be disseminated with the help of retrained librarians, and possibly publishers under contract, who would be in charge of curating metadata so that all articles could be appropriately located by search engines and freely downloaded. The governance of these publishing platforms would be similar to that of other research infrastructures (e.g., large telescopes, particle colliders, or supercomputers). They should be governed by three independent bodies: a scientific committee in charge of selecting the journals allowed to use the publishing platform for free; an executive committee in charge of designing and maintaining the infrastructure (i.e., choosing computers and hiring technical staff, such as software developers, data managers and publishing specialists); and a user committee in charge of reporting problems to be overcome and requests for better or new services.

The financial support needed to offer for free such publishing infrastructures to researchers could be taken from the budget allocated for public research, on the model of what is done for high performance computing with infrastructures such as PRACE (Partnership for Advanced Computing), an international not-for-profit organisation that provides computing and data management resources all over Europe[53]. Another source of funds would be to sell several kinds of supplementary services providing added value, such as editing, translating, converting files into various formats that can be stored and accessed through different media, such as tablets or cell phones (e.g., the *Freemium* business model used by *OpenEdition*[54]). Several publicly owned and publicly funded publishing service units designed to host open access journals already exist in different countries and provide electronic platforms developed using *free open source* software. In France, CLEO (Centre pour L'Édition Électronique Ouverte) publishes in open access more than 400 journals and 3,000 books of human and social sciences, financed using the *Freemium* model and supported by several public institutions such as CNRS (Centre National à la Recherche Scientifique) and Aix-Marseille Université.[55] In Brazil the State of Sao Paolo finances SciELO (Scientific Electronic Library On Line) which publishes in open access more than 1,200 journals from various scientific domains.[56] In Germany, ZBW (Deutsche Zentral Bibliothek für Wirtschaftswissenschaften[57]), jointly funded by the German Federal Government and the States of Germany, provides the publishing platform EconStor[58] which is an infrastructure for the free publication of scholarly literature in economics and business administration, and also publishes the open access peer-reviewed journal Economics. The MPG (Max Planck Gesellschaft) offers similar services, in particular, the platform Edition Open Access for publishing books[59], together with the platform ECHO (European Cultural Heritage Online) that gives open access to rare scholarly collections which has been digitalised.[60]

The public infrastructures, needed for peer-reviewing and publishing *diamond open access* journals, could also be used as open repositories for the *green open access* model. Indeed, they could ensure the dissemination services and long-term archiving of all peer-reviewed articles, published in toll access journals, which have been deposited on the public platform. Moreover, since articles published in *gold open access* can be copied, thanks to their CC-BY license[61], they could also be copied and stored on the same public platform. Many countries have national public libraries and it is time to have in

[53] *http://www.prace-ri.eu*

[54] *http://www.openedition.org*

[55] *http://cleo.cnrs.fr and http://www.openedition.org*

[56] *http://scielo.org*

[57] *http://www.zbw.eu/en/*

[58] *https://www.econstor.eu/*

[59] *http://www.edition-open-access.de*

[60] *http://echo.mpiwgberlin.mpg.de*

[61] *https://creativecommons.org/share-your-work/*

addition *national digital public libraries*, such as the European digital public library (*Europeana*)[62], the Digital Public Library of America (DPLA)[63] and the digital public library of the French *Bibliothèque Nationale* (*Gallica*)[64]. Importantly, these national digital libraries, linked all over the world with other digital libraries and open repositories, could then form the *knowledge commons*[65] that researchers and everybody needs, not only to access articles for free, but also to publish them for free, with the guarantee that they will not in the future be privately owned or retained again behind pay-walls. Indeed, *knowledge commons* should be considered as a public utility, just like air, water and roadways, and hence be publicly owned, or at least publicly regulated.

An important issue is the long-term status of the open access *publishing infrastructures*, which should be publicly owned and have a legal structure which guarantees that they could not be privatised. This is why the start-up model is not adapted for developing them, unless public institutions buy them when they are successful. What has been observed until now is that, as soon as the services of a start-up are adopted by a large number of researchers, a major publisher buys it. Since it has already happened several times in the past, researchers have become reluctant to collaborate with new innovative projects developed by start-ups. For instance, in May 2016, Elsevier bought SSRN (Social Science Research Network), which was the largest open repository in the world (as ranked by Ranking Web[66]). Likewise, the start-up *Mendeley*, created in 2007 by three German PhD students to develop innovative Web-based tools for sharing articles and fostering research collaboration online, was bought by Elsevier in 2013. Moreover, the start-up *Atira*, created in 2012 and funded by the Danish Ministry of Science, Technology and Innovation, developed the software Pure that was used by over 47.000 research staff in Denmark as their CRIS (Current Research Information System). *Pure* was bought in 2012 by Elsevier and incorporated into the software *SciVal* that Elsevier sells to research institutions to evaluate and manage their researchers. As a result, Denmark now pays to Elsevier large amounts of public money to use a software whose development was financed by the Danish government. The open repository *arXiv*[67], which exists since 1990 and has become essential to physicists, mathematicians and computer scientists, might be the next open access platform to be bought by a major publishing company, since its economic model is not yet fully secured. On April 4th 2016, during the *Conference on Open Science* organised by the European Commission, the major publisher Springer Nature has already expressed its intention to buy open repositories to further develop its open access business.

The following actions should therefore be considered:

- *Control of bad practices*. Some publishers enhance the productivity of their business by manipulating the peer review process. Their editorial platform gathers data on the peer reviewing practices of editors and referees in order to develop expert systems able to automatically choose referees, or propose some to editors. They are also able to resubmit the rejected articles to other journals belonging to the same publisher without requiring another peer review, since the same referee reports will be used again. In 2016, Elsevier has even obtained a patent from the US Patent Office for "Online peer review and method"[68]. Another bad practice used by some publishers to artificially increase the impact factor of their journals is to oblige authors, at the stage of proof checking, to add new references to articles published in various journals owned by the same publisher.[69] These practices, which harm the quality of peer reviewing and therefore of scholarly articles, should be detected and exposed, for example by the provision of a platform where researchers could denounce such practices (e.g., as a new service of OpenAIRE). Moreover, editorial platforms should be designed for and with the members of editorial boards and should remain under their control. The data they gather should belong to the editorial boards and no longer to publishers.

[62] *http://www.europeana.eu*

[63] *https://dp.la*

[64] *http://gallica.bnf.fr/*

[65] *Hess, C. and E. Ostrom (2006).*

[66] *http://www.webometrics.info/en/world*

[67] *https://arxiv.org/*

[68] *For example see HTTP://OPENSCIENCE.ENS.FR/OTHER/PUBLISHERS/ELSEVIER/ELSEVIER_PATENT_ON_PEER_REVIEWING/*

[69] *http://openscience.ens.fr/OTHER/PUBLISHERS/ELSEVIER/2012_Elsevier_Bad_Practices.pdf*

- *Sustainability of the European open access infrastructure*. The European Commission's current support the *Open Access Infrastructure for Research* in Europe OpenAIRE[70] could be extended to provide a long-term consistent, stable and sustainable open access infrastructure integrated to the *European open science cloud* presently in project. Its aim is to ensure the interoperability between institutional and national open repositories, all over Europe, and to offer to anyone (researchers, companies, citizens) a unique interface to seamlessly access the content of a very large set of open repositories selected for their quality. For this, it should describe how each open repository is operating (its software, metadata format, legal status, ownership, and funding) and recommend the practices of those offering the best services. It should coordinate and help them to improve the quality of their metadata and guarantee that each article is accessible for free and properly archived.

- *Development of new publishing* services in open access. Such an open access infrastructure should allow the design and experiment new online services. In particular, the European Commission could support the development of new publishing services to help researchers to peer-review, publish and archive the articles they produce. This would be the best way to measure the overall cost of electronic publishing, i.e., the investment and marginal cost (probably negligible), in order to estimate the price publishers could reasonably ask for *article processing charges*. It is very important that such costs become public and known by the researchers. The European Commission could also use new tools, such as the ORCID identification system[71] to uniquely identify the researchers who are awarded EC contracts, or the *Digital Open Access Identifier* DOAI[72] which gives priority to the open access version of any published articles over its version locked behind a pay-wall.

- *Open source software and metadata standards*. Support is needed for the development and documentation of *free open source software* to design open repositories, test them on existing platforms and advertise those which have succeeded to gather a large community of users and developers collaborating together to create new services, thanks to open source software. It is also important that the European Commission remains partner of the Research Data Alliance RDA[73] to actively participate in the definition of international metadata standards (e.g. Dublin Core[74] and NISO norms[75]) which ensure the quality and interoperability of open repositories at international scale.

2.4.4. OPEN PEER REVIEWING IMPROVES THE REPRODUCIBILITY OF PUBLISHED RESULTS

There already exist several publishers offering open peer review options for some of their journals and this can take different forms:

- *open identity peer reviewing*, where the name and affiliation of the referees are disclosed but not their report;

- *open access peer reviewing*, where referee reports are made public and the name and affiliation of the referees could be disclosed or not (e.g., option offered by the commercial publishers *EMBO* Press and Peer J for the journals they publish);

- *open invitation peer review*, where anyone interested can contribute to the peer review process through an open discussion forum provided on the website of the journal (e.g., option offered by the commercial publishers *Copernicus Publications* and *F1000Research* for the journals they publish).

Note that nothing prevents a toll access journal from practicing open identity or open invitation peer review (e.g., it is the case of the four journals published by *EMBO Press*).

Note also that open access peer reviewing was a common practice for scholarly journals in the 19th and 20th centuries. Let us then use here the definition of open peer-reviewing given by Julien Bordier, which

[70] *https://www.openaire.eu/*

[71] *http://orcid.org/*

[72] *http://doai.io*

[73] *https://rd-alliance.org/ and http://europe.rd-alliance.org/*

[74] *http://dublincore.org/*

[75] *http://www.niso.org*

'implies that the referees' reports are disclosed, accessible, signed, and that authors and referees are able to discuss them'.[76]

A few publishers already offer some open peer reviewing tools for the journals they publish. When researchers are able to use for free some large-scale publishing platforms, they will be able to experiment with new ways of peer reviewing and define themselves the tools they need for this. However, before developing such innovative practices, researchers want to make sure that the platforms they use will be long-lasting and will not, as soon as they are adopted by many researchers, be bought by some major publishers who will control them and reinforce their present oligopolistic system which diverts money from research (e.g., Elsevier bought several platforms and associated software : *Collexis, QUOSA, Atira and Pure* in 2012, *Knovel and Mendeley* in 2013, *Newsflo* in 2015 and the *Social Science Research Network* SSRN in 2016). To avoid this, it is essential that:

- the publishing platform be owned, either by one or several public agencies or not-for-profit associations, whose statutes ensure that ownership should remain public or not-for-profit (e.g., the 501 (c) 3 statute);
- the software used to develop those new tools should be free open source and made available to anyone on *GitHub*;[77]
- their long-term financing viability be secured by the same public agencies which fund research programmes, since the production of scientific results and their publication should be integrated. Indeed, it is counter-productive to invest public money in research for discovering new results while allowing companies to privatise the publication of those results to sell them back to researchers who have produced them.

Let us now imagine, as a thought experiment, the cooperation between a journal, owned by its editorial board whose members want to experiment with *open peer-reviewing,* and a publicly-owned publishing platform. Let us consider a researcher who submits an article to a journal and deposits the text, figures and data on the website of the journal. The journal's editor in charge of this article first checks it is not nonsense and then opens it to anyone, but without disclosing the name of the author. During a certain period (e.g., one month) chosen by the editorial board any researcher could referee the article and send a referee report (not only a few comments) to the editor. All volunteer referees are identified with their ORCID (which uniquely identifies researchers[78]) and the editor, after checking that the report is consistent enough and well argued, opens it to anyone on the platform, but without disclosing the referee's identity. Thus, a public but anonymous discussion develops between one or several authors and one or several referees, whose role is to criticise (check for mistakes, originality, readability) and improve the submitted article. When the peer reviewing period (e.g., one month) has expired, the editor takes a decision. If the referee reports are insufficient, either in quantity (e.g., less than three), or in quality, or both, the editor assigns referees, as usually done when peer review is not open, and asks them to send their report as soon as possible (e.g., within less than one month). If the referee reports are satisfactory, the editor decides if the article is accepted, rejected, or requires a revision. If the article is accepted for publication, the editor also evaluates the quality of the referee reports and selects the best ones to be published together with the article. This innovation would be an excellent way to motivate researchers to do peer review, since it would give them the chance to have a new publication together with the recognition of the quality of their contribution as referee (e.g., young researchers who have not yet published an article might be recognised by their peers for having found an error in a calculation, or a flaw in a complex argumentation). As soon as the article is accepted, the name of the authors and their affiliation will appear on the journal's platform. Concerning a selected referee report, the procedure will be different and the choice left to the referee to refuse its publication or to accept it, with her name and affiliation being either disclosed or made public on the journal's platform.

[76] *https://hal.archives-ouvertes.fr/hal-01302597v1*

[77] *https://github.com/*

[78] *http://orcid.org/*

If referee reports are made public during the *open peer reviewing* process, referees will be much more careful in their argument and will avoid requiring that the author quote their own papers, which is a distasteful but very common practice. Keeping the referee reports attached to an article might be highly valuable later on for historians of sciences or ethics committees having to investigate misconduct. Indeed, the current peer reviewing process is obscure and the ownership of all documents produced by editors, referees and authors during peer reviewing belongs to the publisher, who could then destroy them if they have no commercial value. Therefore, another important aspect of *open peer review* would be to preserve those documents in open repositories for future needs.

Summary

The barriers to scholarly publishing and peer reviewing in open access that have been highlighted in this section are not restricted to Europe, but are of great relevance for scientific research worldwide. As with the other challenges considered in this chapter, Europe now has the opportunity to facilitate the practice of *open access* for the sake of *open science*.

2.5 OPEN DATA: CHALLENGES FOR IMPLEMENTATION AND POSSIBLE SOLUTIONS

Ian Mulvany[79]

2.5.1. INTRODUCTION

Calls in favour of Open Data in research are becoming overwhelming. They are made at both national (RCUK, 2015) and international level (Moedas, 2015; Boulton et al., 2012, The Netherlands EU Presidency (2016)). This section will set out a working definition of Open Data and discuss the key challenges preventing the publication of Open Data becoming standard practice. It will attempt to draw some general solutions to those challenges from field specific examples.

Open Data is Findable, Accessible, Interoperable and Reusable (Wilkinson et al. 2016). Making data available is key to support reproducibility, but by far the greatest benefit comes when data can be built upon. This truly assists with the advancement of knowledge. When data is reused there is an immediate return on the investment used for the creation of the original data.

How should we speak of the challenges for Open Data? Goodman et al. (2014) lay out ten rules for the care and feeding of scientific data. Were all of these rules to be adhered to by all researchers, we would have as good an Open Data ecosystem as we could wish for. Let us look at what might be preventing the scientific community from adopting these key practices. To streamline the discussion the ten rules have been regrouped into three core challenges.

2.5.2. CORE CHALLENGE ONE: COMPETENCE IN WORKING WITH DATA

This challenge is addressed by the three rules (Rules one, three and four): Rule 1. Love Your Data, and Help Others Love It, Too; Rule 3. Conduct Science with a Particular Level of Reuse in Mind; and Rule 4. Publish Workflow as Context.

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[79] Ian Mulvany is with eLife Sciences, Sage Publications and not a RISE member. However, this section written by Ian Mulvany has been fully endorsed by the RISE OS subgroup.

Data that is well described and well documented and that follows standards appropriate for its discipline, is more likely to be interoperable with similar data. Such data is more useful than were it to not follow these principles.

A number of potential issues stand in the way of generating data of this level of quality. First, researchers may not be familiar with good data practice. It can also be complicated to keep track of what the researcher did at the point of data capture, requiring later reconstruction when tagging data. A further issue is that new scientific tools coming to market sometimes create proprietary data formats as output formats. Researchers sometimes create custom data formats for their own research (Figshare hosts over 100 distinct mimetypes). Finally, some data is heterogeneous, bringing together multi-varied data across many dimensions, in such a way that only the researcher who created that data understands how to unpick it. However, most of these issues have been successfully addressed within specific domains or communities.

In order to improve researcher skills with working with code, the Software Carpentry organisation has reached over 120,000 students (Wilson, 2016). They conduct two-day workshops instructing researchers on the basics of how to work with software. They have also created a sister organisation whose aim is to do the same, but with data management – Data Carpentry. This is a ground-up effort that is being sustained by the good will of the communities within which these courses happen, and nicely demonstrates the appetite for improved skills amongst software and data intensive researchers.

Many fields have specific standards for data description, and these should be used where they exist. Most core disciplines have appropriate data repositories, but even between similar fields, a lack of harmonisation of data standards can be an issue. The ISA TOOLs (Sansone et al., 2012) initiative can help significantly with creating interoperable data standards in the life sciences, and this kind of data interoperability effort is a good example for other fields that are looking for similar interoperability.

New microscopes have frequently created new data formats. To aid with instrument interoperability the microscopy community created the OMERO[80] framework, a set of standards and software tools, which supports interoperability across over 140 different image formats.

For keeping track of what happens at the point of data collection, smart tooling is an important advance. Digital lab notebooks have a place to play in this Project Juypter[81] offers a digital notebook that supports collaboration, computation, versioning and dissemination of scientific results. Tools can be configured to automatically annotate data at the point of data capture. Rinocloud[82] offers a service that can act as a digital hub bringing together data from multiple machines, into an auto-updated lab notebook.

For heterogeneous datasets capturing metadata about the workflow can be as important capturing the data itself. In the life sciences workflow tools such as Galaxy (Afgan et al. 2016) are being increasingly used. The journal Gigascience[83] now hosts published Galaxy workflows on a sister site GigaGalaxy[84].

Another route for creating compatible data is to make use of data standards bodies. The Open Annotation working group created a data format with a high degree of usage in the digital humanities, and ensured interoperability and openness of that data format through an open standardisation process that led the format becoming a World Wide Web Consortium standard.

There exist many tools and resources for learning good data management practice. Communities are self-organising training to equip themselves with the techniques needed for working in data intensive research. Skills learnt early in a career can form the basis for ongoing improvement and learning.

To address skills gaps training programmes are needed to adopt best practice for data management skills. These training programmes should also include an introduction to tooling that can take the burden off of the researchers for managing their data. Finally, there is

[80] *http://www.openmicroscopy.org/site/products/omero*

[81] *http://jupyter.org/*

[82] *https://rinocloud.com/*

[83] *http://gigascience.biomedcentral.com/*

[84] *http://gigagalaxy.net/workflow/list_published*

a need to encourage the publication and dissemination of good standards and workflows so that researchers can learn by example.

2.5.3. CORE CHALLENGE TWO: APPROPRIATE INFRASTRUCTURE FOR OPEN DATA

This challenge is addressed by the following four rules (Rules two, five, six and eight): Rule 2. Share your data online with a Permanent identifier; Rule 5. Link Your Data to Your Publications as Often as Possible; Rule 6. Publish Your Code (Even the small bits); and Rule 8. Foster and use data repositories.

Data that has an identifier, a stable home, and is well curated is data that is easily findable and accessible. This requires the existence of an appropriate infrastructure (Geoffrey, Jennifer, and Cameron, 2015) for that particular kind of data, be that technical infrastructure (for hosting and issuing of identifiers) or organisational and human infrastructure (for curation, annotation and preservation of the data).

There are, however, still challenges around the creation of good infrastructures. Some fields are experiencing an explosion of data but do not have field-wide infrastructural support for their data. In other cases data is sometimes created at a scale that is beyond the storage ability of even the best infrastructures to store that data. A further challenge occurs when data does not fall neatly into a subject specific repository. Researchers are equally reticent to share code as they are to share data, but code sharing has some unique challenges, such as dependency management and software quality. Moreover, some data needs to be treated with extreme care owing to privacy concerns, and privacy infrastructure is in its infancy. Finally, until recently there has been confusion around how to give credit for data contributions within the literature.

Good infrastructure does exist for data in many domains of research (e.g. high energy physics (CERN, 2009), astronomy, genomics (Benson et al. 2013, Berman, 2000)), however there are emerging domains for whom lack of good infrastructure is becoming a critical problem (e.g. high throughput and resolution microscopy, conectomics (Lichtman, Pfister, and Shavit 2014), computational social science). These domains share a common pattern where the tools used have reached new levels of sophistication and as a result data generation from these tools has expanded at a rate that is much faster than had been anticipated within their fields. This is leaving these fields in a momentary state of data crisis. A solution to these kinds of crises is to encourage the funding of data infrastructure, however whether this should be done on a project level, institution level, national level, or even international level remains an open and unresolved question. Building on many reports on the challenges of data infrastructure Knowledge Exchange (2016) recommends taking into account the full research cycle when thinking about funding infrastructures, and to look to the US where the NSF has a dedicated programme for the creation of shared data-centric cyber infrastructure[85].

Even for data at large scale where good infrastructure does exist, it is often not possible to preserve all of the data. It is instructive to look at how high energy particle physics deals with its data storage requirements. CERN (CERN, 2009) outlines four levels of data preservation. First, retain only the publication that the data ended up generating; second, preserve the data in a simplified format, this might be for outreach or training purposes; third, preserve the analysis software and specification of the data format; and, finally, preserve the full reconstruction level data, and possibly some of the original data.

It is understood that much of the primary data coming off the detector will have to be discarded, and so their data preservation framework allows them to make decisions on what to keep based around the expected future uses of that kind of data.

It may be possible with other emerging high resolution data sources to also find ways to make decisions around whether we can preserve certain artefacts that are of lower dimensionality of the original source data. For example in connectomics one begins with high resolution images of brain slices, and a full 3-D image of a brain can be on the order of petabytes of data, however the final network diagram showing the interconnection of the neuronal scaffolding of a brain will be many orders of magnitude smaller than the original images.

85) *http://www.nsf.gov/cise/aci/cif21/CIF21Vision2012current.pdf*

Another strategy, where large scale data is concerned, is to look to use peer to peer systems for data sharing. The tool dat data[86] uses a bit-torrent like protocol to allow the creation of a pool of nodes for sharing data. It has been successfully used to overcome network bottlenecks in the sharing of genomic data across Sudan.

About 70% of the lifetime cost is incurred on first write to disk. Given the current rates at which the prices of long term data storage are dropping (in 1980 1GB of data storage cost $193,000 in 2015 $0.03 (Komorowski, 2015)), the question of which data sets do we need to make strategic decisions around when it comes to large storage costs will probably always be with us, but our view on the kind and size of what that data is, will constantly be changing.

In terms of numbers of data sets, most researchers producing data are not producing data at large scale. The questions around how they can create good identifiers for their data, and how they can find appropriate locations to deposit their data, are equally important as for those of large data. For subject specific data there usually exists a subject specific repository. The Registry of Research Data Repositories lists over 1500 research data repositories. The journal Scientific Data also maintains a more curated list. For data that does not naturally find a home in one of these repositories there are also generic data repositories such as Figshare, Zenodo, DataDryad, Imeji and Github. Each of these will allow a researcher to post a public version of their data with an appropriate identifier, usually a DOI. The main challenge here is in increasing awareness amongst researchers about these resources.

Data is often derived as an output of some analysis pipeline. For true reproducibility and reusability the software that was created to analyse the data also needs to be made openly available. This comes with some specific challenges around how to preserve that code, how to ensure that the code can run for other researchers, and how to manage code dependencies. The ENCODE project (Hong et al., 2016) tackled these problems by making virtual machines available that include all of the project data and software. Increasingly in the commercial software world treating all software and hardware dependencies as code is becoming standard practice and this allows entire software stacks to be reproducibly built from a descriptive formula (K Morris, 2016).

Privacy of data is a critical issue, however the number of domains in which this is a concern is a small subset of all research domains that are producing data, so one should caution that the discussion around privacy needs to be taken seriously, but at the same time should not dominate the debate around policies for making data available where privacy is not a concern. The mantra "Open Where Possible" should be followed.

One last critical piece of infrastructure that is required for a healthy Open Data ecosystem is the ability to give credit to data. Within scholarly publishing this is done through enabling data citation. Between 2012 and 2015 a FORCE11 working group created the data citation principles (Altman et al., 2015). All stakeholders in the scholarly enterprise should treat data as a first class citizen, and cite it appropriately. The standard XML used in scholarly publishing has also been updated to support data citation (Mietchen et al., 2015). Journals need to encourage good data citation practice, and need to ensure that data is acknowledged correctly. For example the open access journal eLife requires author list any novel data that they create in the course of writing their paper, along with giving credit to any previously published data that they used as part of their investigation.

Responding to core challenge two therefore requires a smart preservation of data, taking into account the full research lifecycle. There is also a need to increase the awareness of the many data repository options that already exist, and to require deposition into an appropriate repository for any given data set. In addition, data infrastructure needs must be continually reviewed, at national and trans-national levels. Finally, data should be cited as a first class object.

2.5.4. CORE CHALLENGE THREE: CREATING A SUPPORTING CULTURE FOR OPENNESS

This challenge addresses the three remaining rules (Rules seven, nine and ten), and can be summarized by asking how we can ensure that the correct incentives are in place to support the sharing of open data: Rule 7. State How

86) *https://datproject.org/*

You Want to Get Credit; Rule 9. Reward Colleagues Who Share Their Data Properly; and Rule 10. Be a Booster for Data Science.

Irrespective of how good data management skills are, or how sophisticated data hosting infrastructure is, unless there is a willingness on the part of the researcher to make their data open, then no data sharing will happen.

For the researchers they have to put time into making their data available, and they need to feel sure that this time would not be better used in helping their careers were they doing something else with that time, such as writing grant proposals, or working on new experiments. In some cases researchers may even have a misguided fear of sharing data in the belief that by do doing so they will lose out on publishing potential results that they may have otherwise been able to obtain from the data set (see The International Consortium of Investigators for Fairness in Trial Data Sharing, 2016).

To overcome these fears, researchers' motivations to share data need to outweigh their misgivings towards data sharing (see also section 2.3 for further discussion of this issue).

There are two strategies that can be taken towards this. The first is to make data sharing mandatory in order to receive grants or to achieve publication. The second approach is to fairly reward data and software producers for their efforts on their own merits. This is more desirable, but significantly harder to do.

Mandatory data sharing is most common at the journal, funder and discipline level. Since 2014 PLOS has required data to be made available for publication across all of PLOS journals. This has led to a significant increase in the number of articles published that also make their underlying data available. The Wellcome Trust requests that data be made available, and the Bill and Melinda Gates Foundation require all data to be made available. From a grassroots effort the disciple of crystallography evolved to one in which data sharing is now mandatory. Ad hoc practice became codified as required practice (Berman et al., 2008). This seems to have been an example of where an initial tight-knit community recognised the value of data sharing, and as that community grew those values of data sharing grew with it.

A greater challenge is how to change implicit behaviour. In order to do this the reward system needs to be modified to ensure that researchers get appropriate credit for the creation of data and code. There is strong evidence that open publication practices reward researchers through more citations, access to better collaborations and easier adherence to funder mandates (McKiernan et al., 2016). In particular those papers that make their data available garner more citations than those that do not (Piwowar and Vision, 2013). Nonetheless researchers remain fixated on articles, and in particular articles in "high-impact" journals, as the primary means of validating their work. Ironically it is usually researchers that are assessing other researchers on grant award panels, or hiring committees. These bodies need to be given clear and unambiguous instruction to reward researchers based on their full scientific contribution and the adoption of the San Francisco Declaration on Research Assessment should be mandatory for all such bodies.

To support a more nuanced way of assessing research continued investigation of altmetrics is recommended. Tools like Depsy, which indexes research software and gives information on its reuse, can help to highlight the impact and contribution of this software. Finding a way to do something similar for research data is critical (Kratz et al., 2015).

Making data or software specific positions available within the academy can also create career opportunities for researchers whose contributions are critical, but currently undervalued by the current research assessment system.

Addressing this third core challenge requires, where possible, that data sharing is made mandatory for the receipt of grant funding or for publication of research articles. Fields that have good data sharing practices should be supported and rewarded through infrastructure support for data repositories. Grant awarding committees must be educated about best practice for research assessment, while in parallel, funding for explicit data and software career tracks should be created. Finally, ways to measure and reward data reuse should be developed and supported.

2.6 OPEN SCIENCE AND RESEARCH INTEGRITY

Mary Ritter

2.6.1. INTRODUCTION

Research integrity is essential throughout all scientific endeavour, with researchers responsible and accountable, and research output reproducible and of the highest quality. Without it, data are at best worthless, although often with serious consequences. At worst, poor data are positively dangerous, for example in the case of clinical trials. The integrity of research therefore lies at the very foundation of Open Science. Importantly, Open Science is not only critically dependent upon the integrity of research that is open to all; Open Science also has the potential to reveal where a failure in research integrity has occurred.

Commissioner Moedas has put strong focus on research integrity in his Open Science, Open Innovation and Open to the World agenda, launching work on a new European Research Integrity Initiative, with clear standards and mechanisms to tackle scientific misconduct. Actions launched by the Commission include: "cooperation with stakeholders to review the European Code on Research Integrity (ALLEA/ESF code); the creation of a European Research Integrity Community; promoting a research integrity culture through capacity building, awareness and skills; and efforts to increase reproducibility, exchange of best practice and international cooperation" (Open Science MASTER, February 2016).

The RISE Open Science Group's work is intended to complement the Commission's approach, focussing particularly on the role of research culture in supporting and promoting research integrity, and investigating ways in which this can be enhanced through shared standards, understanding and experiential training programmes. Arising from this work, the following actions should be considered:

- make the revised ALLEA-ESF code binding across all EU countries and countries receiving EU funding to ensure comparable shared high standards;
- support this code with experiential training programmes developed and specifically tailored for early researchers, and for senior researchers; and
- conduct research to assess the impact efficacy of training programmes.

The rationale and further detail concerning these recommendations is given in the following text. However, it is first useful to put the problem in context with a brief background to the area. A detailed review is given in the recent briefing paper from Science Europe.[87]

2.6.2. DEFINING RESEARCH INTEGRITY

Research integrity has no single accepted definition, but can be defined as the responsible conduct of research and is intrinsic to the value of research and the trust that it engenders. The *Loss of research integrity* covers a range of problems that form a continuum from questionable research practice through to research misconduct.

Research misconduct is probably quite rare, but is what hits the headlines. It covers what is referred to as FFP – Fabrication of data, Falsification of data and Plagiarism, and has now become a research topic for criminologists.

More frequent, but harder to define is the grey area of irresponsible/questionable research conduct, resulting from either deliberate or unintentional/sloppy actions. While a meta-study has shown that almost 2% of scientists admitted to a form of FFP, a shocking ~33% admitted to questionable research practices (Fanelli, 2009). Because of its prevalence, irresponsible/questionable research conduct is therefore potentially more damaging than the more obvious research misconduct/FFP.

The OECD has reviewed the areas involved in irresponsible/questionable research conduct in detail[88]. Broadly, these cover:

- Research practice (e.g. poor methodology, poor experimental design);
- Data-related (e.g. not preserving primary data, trimming data, withholding data);

87) *http://www.scienceeurope.org/uploads/PublicDocumentsAndSpeeches/WGs_docs/Briefing_Paper_Research_Integrity_web.pdf*

88) *https://www.oecd.org/sti/sci-tech/40188303.pdf*

- Publication-related (e.g. claiming undeserved authorship or denying deserved authorship);
- Personal (for example: inadequate leadership and mentoring);
- Financial and other areas (e.g. peer review abuse, non-disclosure of conflict of interest).

2.6.3. THE IMPACT OF LOSS OF RESEARCH INTEGRITY

The loss of scientific integrity has wide-reaching effects far beyond the specific scientific area of the work involved. This breadth of impact includes the following aspects:

- Society loses its trust in science;
- Public and private funding is squandered (for example, NIH has estimated a cost of US$1.67 billion over 20 years) (Stern, A.M et al., 2014);
- Valuable professional time is wasted in research based on previously published misleading data;
- Careers of co-workers, in particular students, can be destroyed. For example a PhD student's thesis may be based on a supervisor's misleading data, and/or joint publications that have to be withdrawn – with devastating impact on the student's career progression;
- The outcome may be dangerous (e.g. in health research such as clinical drug trials).

2.6.4. HOW CAN RESEARCH INTEGRITY BE ENSURED?

There are currently three main approaches that have been taken to ensure research integrity. First, there are Statements, Codes of Practice and Concordats that provide clear statements concerning the principles and components of research integrity. There are a number of these produced at organisation, national or international level, and they are designed to provide the overarching framework within which research can be conducted with integrity. Second, there are review processes and punishments that have been developed to deal with research misconduct when it does occur. Such processes are usually developed and followed at the level of individual research institutions or research funding organisations. Thirdly, there are training programmes that are aimed broadly at raising awareness of research integrity and misconduct, in order to prevent or minimize its occurrence. Each of these approaches has a key role to play, and examples are discussed below.

Research Integrity Statements, Codes of Conduct and Concordats

For Europe to practice Open Science, the most effective Statements, Codes of Conduct and Concordats will be at European and global level. Two examples are given below: those produced during the World Conferences on Research Integrity and that produced by the European Science Foundation (ESF) and All European Academies' ESF/ALLEA.

The 2nd World Conference on Research Integrity, held in Singapore in 2010, produced the "Singapore statement"[89]. This represented the first international approach to drafting shared principles on research integrity. The document was first drafted by small group before the conference, and then developed from contributions submitted to the conference and from output from the conference itself. Finally, the statement was discussed in plenary session at the end of the Conference, and amended in light of this and subsequent feedback. It was an impressive and very effective consultative process, leading to an overall international consensus on the key elements of research integrity.

Building on this, the 3rd World Conference on Research Integrity, held in Montreal in 2013, produced the "Montreal Statement on Research Integrity".[90] This followed on from the Singapore statement, but focussed on collaboration across national boundaries. A further, 4th, World Conference on Research Integrity was held in Rio in 2013, and the 5th will take place in Amsterdam in 2017.

[89] *http://www.singaporestatement.org/downloads/singpore%20 statement_A4size.pdf*

[90] *http://www.researchintegrity.org/Statements/Montreal Statement English.pdf*

The Singapore Statement starts with: "The value and benefits of research are vitally dependent on the integrity of research. While there can be and are national and disciplinary differences in the way research is organized and conducted, there are also principles and professional responsibilities that are fundamental to the integrity of research wherever it is undertaken." It highlights the principles of: Honesty, Accountability, Professional courtesy and fairness, Good stewardship. It also identifies 14 responsibilities: Integrity, Adherence to Regulations, Research Methods, Research Records, Research Findings, Authorship, Publication Acknowledgement, Peer Review, Conflict of Interest, Public Communications, Reporting Irresponsible Research Practices, Responding to Irresponsible Research Practices, Research Environments and Societal Considerations.

ESF/ALLEA European Code of Conduct for Research Integrity. ALLEA-ESF Code of Conduct[91] makes it clear that "researchers, public and private research organisations, universities and funding organisations must observe and promote the principles in scientific and scholarly research." These principles include: Honesty in communication, Reliability in performing research, Objectivity, Impartiality and independence, Openness and accessibility, Duty of care. Fairness in references and giving credit, Responsibility for scientists and researchers of the future. Work on developing a revised version of this important ALLEA-ESF document is currently in progress via stakeholder consultation.

There are, in addition, other related documents operating at the level of individual national bodies and research funding organisations, both within Europe and on the international stage. Although there is a common thread that runs through them all – clarifying the core principles and components required for research integrity, content varies considerably.

The new ALLEA-ESF Code of Practice therefore has the potential to be the key benchmark for all Europe – overcoming the many differences that currently exist between European countries.

Recommendation 1: That the ALLEA Code of Practice is made binding for all countries within the European Union and for those non-EU countries receiving EU science funding[92].

What happens when things go wrong? How are research misconduct and questionable practice dealt with?

Most institutions and funding agencies in Europe have clear structures, procedures and penalties to deal with research misconduct (FPP). For example, the ERC has the "ERC Scientific Misconduct Strategy"[93] developed by the Standing Committee on Conflict of Interest, Scientific Misconduct and Ethical Issues (CoIME). However, the situation is different for questionable research practice since this is more complex and much harder to clearly define and hence to deal with. As a consequence, there is much variation in the actions, if any, that organisations take.

It is beyond the scope of this paper to review the range of practices for dealing with research misconduct and questionable practice. Addressing this, and developing a pan-Europe approach, is a major goal for the Commission's current work programme.

The culture for research integrity: why does research misconduct and questionable research happen and how can we address this?

A key area to consider is the culture within which research is conducted. This is partly driven by the overall science environment – the funding, publishing and career assessment processes that govern much of scientific life. It is also strongly affected by the environment of individual institutions, departments, laboratories and research groups. In this latter case, it is the senior research staff that play a key role since it is their example that very much creates the local research environment within which more junior researchers work. A more recent influence now comes from social media such as ResearchGate, Academia.edu and Mendeley, which, while providing a much more open shared

[91] *http://www.allea.org/Content/ALLEA/Themes/Scientific%20Integrity/Code_Conduct_Research_Integrity.pdf*

[92] *The new revised ALLEA European Code of Conduct for Research Integrity was launched and presented to Commissioner Moedas on 24 March 2017, after going to print with this book. The code is available at: http://bit.ly/2nVbJRC*

[93] *https://erc.europa.eu/sites/default/files/document/file/ERC_Scientific_misconduct_strategy.pdf*

environment, also exert cultural pressure – perhaps highlighting the most popular research rather than research of the highest scientific merit.

The topics of 'funding' and 'publishing' are subject of separate sections in this chapter from the RISE Open Science Group (M.Carey, section 2.3; M. Farge, section 2.4). Here, the focus will be the research culture, how this can influence research behaviour, how training programmes could address and improve the situation, and which training modality could be most effective.

Research misconduct and questionable research is likely to result from a complex interaction between an individual's personality and external environmental/ culture factors, including:

- Pressure of time and/or perhaps laziness;
- Sloppy methodology, analysis and presentation of research;
- The impact of peer review of grant applications and manuscripts and reliance on journal impact factors instead of evaluation of the science itself;
- External priorities and pressure (the supervisor, the group, the department, the institution);
- Short length of papers (journal requirements) so that methodology and data are omitted, leading to problems of testing reproducibility;
- Salami slicing of papers to boost the curriculum vitae, resulting in too few data (or repetition of data) in each paper – hampering full assessment

Enhancing the culture for research integrity: what can we do?

The Commissioner's new European Research Integrity Initiative, with clear standards and mechanisms to tackle scientific misconduct will play a key role in setting the research framework and working towards common shared practice across all institutions in Europe.

To complement this, the RISE Open Science group has focussed on the development of a shared European culture that firmly supports research integrity. As discussed, the external drivers of 'publication' and 'funding' are dealt with in sections 2.3 and 2.4). The focus here will be the internal drivers: the institutional/ research group environment and behaviour of individual researchers, together with potential skills and experiential training programmes that could be developed to enhance the environment for research integrity. This provided the basis for an extensive discussion with the invited external specialists at the RISE Open Science Workshop, Mallorca, May 2016.

At present, there is considerable inter-institutional variation, with some institutions having no training programmes at all while those that do focus mainly on early researchers. In addition, the modality of training differs between institutions, with an increasing focus on on-line programmes run by individual institutions, funding bodies (e.g. NIH) and commercial companies (e.g. Epigeum[94], used by EMBO and many universities). These programmes are an important component in research training. However, there is mounting evidence that experiential training may be the most effective way to create beneficial culture change.

To develop experiential training, it is important to understand the context and environment in which researchers work[95]. Early researchers feel they have no control over the research culture in which they work. Often the pressure means that they are too busy, too rushed and too insecure to raise issues that concern them. Scientists are trained to talk about their science but are less good talking about personal things that concern them, such as problems in the working culture. Experiential training involving 'Open dialogue' could expose problems, share the learning and provide the confidence to deal with them – to the benefit of the researcher, good science and research integrity. It might also help to combat the loss of talented researchers who leave the profession because they cannot cope with the current culture. Dissemination, university 'buy-in' and sharing of such training programmes could be mediated by collaboration with bodies such as the European Universities Association (EUA) and their Council for Doctoral Education (CDE)[96], as has been

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94) *https://researchskills.epigeum.com/*

95) *http://nuffieldbioethics.org/wp-content/uploads/Nuffield_research_culture_full_report_web.pdf*

96) *http://www.eua.be/activities-services/cde/eua-cde-steering-committee.aspx*

successfully done for broader doctoral skills training. Embedding such training into the requirements of funding organisations would also help to promote the required cultural change.

It is also clear that it is the Senior staff, the Principle Investigators (PIs) and Group Leaders who set the research culture and research environment for their institution, department and research group – within which the more junior researchers work. Such environments vary considerably: some measure success entirely by publication in top journals and grant income, others take broader contributions to science and to their institution into account; some are hierarchical, others are not; in some the group head insists on being named on every publication, others do not; in some the pressure to produce data is excessive, while others may go to the other extreme. This all has an impact on the early researchers and on the way in which they conduct their research. Thus, not only do the early researchers need to understand these differing pressures and know how to deal with them (Recommendation 1 above), but the senior staff need to understand the impact that their standards and behaviour have on the more junior researchers – and the implications for research integrity. Hence, the development of tailored training programmes for PIs and Group Leaders is also an important tool for supporting and enhancing research integrity, although this area is currently quite limited and needs work on determining what modality is best suited bringing senior staff 'on board'. Dissemination via organisations such as the EUA and through funding body requirements would also be effective for training of senior staff, as proposed for early researchers.

Recommendation 2: It is proposed that the European Commission supports the development and dissemination of a shared portfolio of experiential training in Research integrity for early researchers (PhD students, postdoctoral researchers), together with a separate specially tailored portfolio for senior researchers, based on a review of current best practice and de novo development. Collaboration with the European Universities Association and its Council for Doctoral Education will enable dissemination across Europe.

Key issues to consider will be:

- What type of training is best how to reach hearts and minds and avoid a compliance/'box ticking' approach;
- How to make the training relevant to individuals, yet in the context of public academic standards;
- How to reach all individuals – those most in need may be the hardest to reach;
- The training must have long-term impact for an individual, throughout their career.

The last bullet point leads on to the final key issues to be addressed: how do we know which training programmes have the greatest and longest-lasting impact. There are two, linked, approaches to answering this question: research into efficacy and indicators of impact. For the latter, a report from the European Commission suggests a framework with 8 criteria for assessing the impact of different initiatives, while the SORC (Survey of Organisational Research Climate) has been developed and used with some success in the US[97] (Martinson et al., 2013). For the former, research into the long term efficacy and impact of different training programmes is a very important but difficult area of investigation where some progress has been made, but much needs to be done.

Recommendation 3: that the European Commission supports a research programme into the efficacy and impact of the different modalities of research integrity training programmes, to inform future development and improvement of such programmes.

In summary, Europe has a unique and timely opportunity to provide a continent-wide shared Code of Conduct, supported by novel and high efficacy experiential training, to develop and bring the culture of excellence in research integrity to the highest of global standards. With this achievement, Europe will have a unique opportunity to lead the world in Open Science.

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97) *http://ec.europa.eu/research/swafs/pdf/pub_rri/rri_indicators_final_version.pdf*

2.7 POLICY IMPLICATIONS

Mary Ritter

Using an evidence-based approach, the analysis in this chapter has identified four key issues that, if not addressed, will seriously impede Europe's ability to implement and lead the world in Open Science. These issues are summarized below, including recommendations on how to address them.

1. *The current funding climate presents major barriers to Open Science*

The biggest problems are low success rates and the need for more PI-driven (single beneficiary) research funding.

It is impossible to select "best" proposals when success rates are low. The following actions should therefore be considered:

- The use of evaluation metrics such as number of publications and journal impact factors should not be allowed to substitute for meaningful assessments of the content and quality of an individual's work;
- Candidates should be allowed to highlight their major scientific contributions, by creating their own narratives;
- Applications must be reviewed by the most highly qualified experts possible. This may require additional members on evaluation panels, with expertise to cover more subdisciplines, as well as more remote evaluators per proposal;
- Pre-registration of reviewers should be removed; it creates an undesirable barrier to obtaining input from the most highly qualified experts.

PI-driven funding opportunities should be increased:

- Funds should be shifted away from large-scale collaborative projects towards PI-driven funding;
- Overall simplification of granting schemes: build on the most successful programmes (ERC);
- Because of the proven difficulty in predicting which projects will be successful, it is critical to support as many highly qualified researchers as possible, particularly early in their careers. The allocation of funds should be adjusted so that all applications that meet key evaluation quality criteria and are considered fundable receive some funding, even if the total awarded for some or all grants needs to be reduced relative to their originally proposed budgets.

Low success rates increase the preparation, evaluation and administrative burden. The following, therefore should be considered:

- General adoption of two-stage application processes to minimize significant loss of research productivity that currently occurs on both preparation and evaluation sides due to extremely low grant success rates;
- Elimination of grant deadlines.

2. *Science cannot be open because publishing is currently dysfunctional*

Access cannot be considered open when many peer-reviewed journals, publishing platforms and bibliometric tools are owned by major commercial publishing companies. The following actions should be considered:

- Publication should be part of the continuum of research, led by scientists using public publishing platforms serviced, but not owned, by the commercial sector.
- The Green Open Access/ self-archiving model should be endorsed, with an Open Access 'button', as the most immediate solution for Open Access publication. For this, an archiving platform (e.g. Zenodo-OpenAIRE) with long-term consistent funding (not dependent on project grants) is required. Green Open Access provides the flexibility to test different business models before more optimal solutions (such as Diamond Open Access) can be designed and adopted by researchers;
- Funding criteria should be aligned with Open Access goals. The European Commission should instruct reviewers and review panels for all EC-funded grants to accept preprints as evidence of productivity in grant applications and reports. Assessment criteria should also explicitly and directly reward open access publishing, data sharing, and open resource development.

3. *Many researchers do not have either competence or confidence in the practice of Open Data*

Competence in working with data, establishing appropriate infrastructure, and creating a supporting culture for openness are three core challenges for Open Data. The following actions should be considered:

- Development of training programmes to adopt best practice for data management skills;
- Promoting an increase awareness of the many data repository options that already exist;
- Support for ways to measure and reward data reuse, e.g. encouraging direct citation of data, educating grant award committees about assessment, and creating funding for explicit career tracks for data and software career specialists.

4. *Research funding must not be wasted on unreliable data*

The understanding and practice of research integrity is very variable across Europe. The following actions should be considered

- The ALLEA-ESF Code of Conduct should be made binding for all EU countries, and for countries receiving EU research funding, to ensure shared European high standards of research integrity;
- This gold standard of research integrity should be firmly supported by the development of experiential training programmes specifically tailored for early and for senior researchers – to create the culture within which research integrity for Open Science can flourish. (Dissemination and stakeholder 'buy-in' should be actioned in collaboration with the European Universities Association (EUA) and its Council for Doctoral Education (CDE)).

Realigning European funding, support for Green Access, and creating the conditions for Open Data and Research Integrity – with the goal of an Open Science culture of excellence – will not only encourage Open Science practice within Europe, it will also improve research conditions and enhance Europe's attractiveness for top researchers. This is a chance for Europe to lead a global shift towards Open Science culture that promises to positively impact the acceleration of discovery and innovation worldwide.

Chapter 3:

Open to the World

TABLE OF CONTENTS

3.1. Introduction ... 97

3.2 Science, Technology and Innovation for Sustainable Development ... 99

- 3.2.1. The decade for solutions ... 99
- 3.2.2. Global consensus on societal challenges ... 100
- 3.2.3. The EU value added comes from long-term and systemic frameworks ... 101
- 3.2.4. EU's strengths in addressing global societal challenges ... 103

3.3 Science Diplomacy ... 106

- 3.3.1. Introduction ... 106
- 3.3.2. Background and History of Science Diplomacy ... 107
- 3.3.3. Scope and Limits of Science Diplomacy ... 108
- 3.3.4. Science Diplomacy in the EU ... 109
  - 3.3.4.1. Science in Diplomacy ... 110
  - 3.3.4.2. Science for diplomacy ... 111
  - 3.3.4.3. Diplomacy for science ... 111

3.4 Tools for Science Diplomacy in the EU ... 113

- 3.4.1. Introduction ... 113
- 3.4.2. Classifying tools for Science Diplomacy ... 113
- 3.4.3. Strategic Tools for Science Diplomacy at national level ... 115
- 3.4.4. Operational tools for Science Diplomacy at the national level ... 115
  - 3.4.4.1. Bilateral or Multilateral S&T Cooperation Agreements ... 116
  - 3.4.4.2. S&T advisory boards ... 116
  - 3.4.4.3. S&T Advisors attached to Embassies or Foreign Affairs Departments ... 116
  - 3.4.4.4. Opening of National or Regional Research Funding Schemes ... 117
  - 3.4.4.5. Support tools at the national level ... 117

3.5 Policy implications ... 118

CHAPTER 3
OPEN TO THE WORLD

3.1. INTRODUCTION

Ivo Slaus and Helen Wallace

For Europeans to be "Open to the World"[98] is vital in a period when the openness of the world has itself become a matter of contention. Many of the challenges that we face at home and across the globe require active and effective international collaboration and the harnessing of state-of-the art science. Global societal challenges are intertwined with local and regional challenges. Local issues, such as failed and failing states or disputes over trans-boundary resources can turn into global threats. Global problems, such as climate change, environmental degradation, water shortages, energy and food insecurities and population changes can translate into local conflicts. To be Open to the World requires insistence on open economies and open societies so as to strengthen human capital and preserve natural capital. In an interdependent, rapidly changing world new threats and new challenges constantly emerge, but also new opportunities.

In this chapter the RISE expert group on Open to the World explore ways in which the European scientific communities can play their part in addressing global societal challenges. This leads us to reflect on how we mobilise our scientific resources, what we prioritise, and where we focus our efforts geographically. There is a need for an ambitious plan of action in a context where the European Union is committed to becoming a stronger global actor. This ambition requires bringing together more closely our scientific endeavours with the core strands of the European Union's external policies – and it also an investment in engagement with partners across the globe. Both the policy communities and the scientific communities will have to develop new ways of working for this ambition to be more than a pipedream.

None of the challenges facing us can be overcome just by hard power – military and/or economic. Politics should not be a zero-sum game; it should be a win-win game. The constructive deployment of science, technology and innovation (STI) can help to increase the likelihood and benefit of win–win games. Therefore, science, technology and innovation are vital "tools" of soft power in the search for mutually acceptable solutions to common challenges. The interplay of STI with policy-making, decision-making, foreign policy and international politics forms the basis for science diplomacy, which is explored half way this Chapter in section 3. The European research communities already constitute a major science hub and much more could be done to build on their assets, as indicated in the discussion of tools for science diplomacy in section 4. Together the EU's programmes combined with those of our member states provide a strong basis for engagement with the rest of the world. Europe accounts for over 30 % of the world's scientific production. Research programmes and institutions in Europe – whether those of the European Union (EU) such as Horizon 2020, or inter-governmental ones such as the European Organisation for Nuclear Research (CERN) or the European Molecular Biology Organisation (EMBO) – promote worldwide scientific endeavour. The EU is one of the two largest economies in the world and is the top trading partner for eighty countries.

The case for mobilising these assets even more actively is clear. After all the interests of citizens of Europe and specifically those of the European Union (EU) are global interests. In particular there is agreement on the need for the EU to contribute actively to achieving the sustainable development goals (SDGs) set by the UN General Assembly[99]. Section 1 identifies the issues and some ways in which a redoubled effort could facilitate progress to this aim, as our case studies illustrate. An emphasis on the SDGs is also a contribution to global

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[98] *The RISE Open to the World group consisted of Ivo Slaus (chair), Helen Wallace, Marga Gual Soler, John Wood, Kerstin Cuhls, Jorge Manuel Lopes Moreira da Silva.*

[99] *Transforming our world: the 2030 Agenda for Sustainable Development was agreed by consensus on 2 August 2015 at the informal meeting of the UN General Assembly plenary and adopted on 25 to 27 September 2015 at the UN Sustainable Development Summit. The full text is available at: https://sustainabledevelopment.un.org/content/documents/7891Transforming%20Our%20World.pdf*

security, another goal shared by Europeans. The EU also has the responsibility and the opportunity to draw on its assets to promote more effective global governance, global security and the eradication of poverty and hunger. The EU has experience on which to build both substantively and in its ways of working, for example through institutional partnership between member states and the Union and regional approaches for science and technology agreements.

Scientists can play a part in all of these endeavours. Structures invented, initiated and developed through international scientific cooperation, such as CERN, and recently SESAME (Synchrotron-Light for Experimental Science and Applications in the Middle East), or those established by the EU (such as Horizon 2020) are large experimental endeavours involving thousands of researchers. They can serve as global role-models on both scientific and political levels. Horizon 2020 is open to researchers from across the world. It addresses global societal challenges and supports EU external policies (European Commission, 2012). Moreover, the European Research Area (ERA) could be enlarged to a Global Research Area thereby strengthening the role of science, technology and innovation in achieving sustainable development goals and meeting other global societal challenges[100]. For such ambitions to be achieved does, however, require a 'social contract' between the scientific communities and the policy communities. Dialogue needs to be closer and scientists need to acknowledge their responsibilities for contributing to public understanding, just as policy-makers need to engage more closely with the scientific communities. Therefore, this will require new ways of working and hence our concern to develop closer mutual understanding. In particular, much rests on the evolving role of those who are currently early career researchers and much rests on adjusting to a context in which social media are changing the way in which we communicate transnationally.

IdeaSquare at CERN

Development work is shifting from traditional researcher-developer-manufacturer relationships to collaboration to co-creation in order to compact development time and minimize risks involved." Therefore one of Ideasquare's intentions is to test and see whether design thinking could augment the already existing ways of doing research and knowledge transfer at CERN. Among other initiatives Challenge Based Innovation (CBI) is a project course, where multidisciplinary student teams and their instructors collaborate with researchers at CERN to discover novel solutions for the future of humankind. The projects are an elaborate mixture, where the technologies derived from research at CERN meet societal, human-driven needs.

Students come from a mix of disciplines, countries and universities. They believe that the wildest combinations will produce the most delightful outcomes. So far they have worked with students from industrial design, electrical and mechanical engineering, a variety of economists and business students, architecture and robotics.

Ideasquare is a prototype project being followed on by the much larger ATTRACT which is a consortia of several large European laboratories such as the European Molecular Biology Laboratory and the European Southern Observatory in conjunction with the ESADE Business School and Aalto University in Finland to expand the concept further. Experiments such as these bring about whole body solutions to real challenges fast. The EC has already supported projects at IdeaSquare and this concept can be used more widely in conjunction with students from developing nations to drive through ideas of lasting benefit.

[100]) As discussed during the Workshop "Open to the World" and international research cooperation during the Conference 'European Research Are@. Link. Shape. Develop.', which took place in Berlin, 10 October 2016.

The potential agenda for increased engagement by way of Open to the World is huge. This chapter lays out a possible template for developing a Europe-Africa Partnership on Research and Innovation. Several individual member states already have collaborative scientific programmes with African countries and the EU has a variety of mechanisms of engagement. More could be done to pull these together into a more concerted approach.

This "Open to the World" chapter formulates some overarching policy options emerging from our RISE expert discussions. It sets out the reasons for which it is timely for the EU and its member states to make a determined effort to extend the reach and the range of science diplomacy as an essential contribution to improving the effectiveness of the EU as a global actor. The recommendations are summarised in the concluding section 3.5. Of course science diplomacy on its own can contribute to but not solve the challenges that we face. Its deployment needs to be integrated with other tools of diplomacy. However, given the important assets of scientific achievement by Europeans, it would be irresponsible not to develop a more focused strategy for harnessing our research and scientific resources more effectively at a global level.

There is a need to grasp the opportunities offered by science and technology to address and hopefully solve, or come up with solutions to, the many global societal challenges Europe, as well as most other countries in the world, is confronted with.

3.2 SCIENCE, TECHNOLOGY AND INNOVATION FOR SUSTAINABLE DEVELOPMENT

Jorge Moreira Da Silva and John Wood

3.2.1. THE DECADE FOR SOLUTIONS

As demonstrated in several reports, without science and technology humanity cannot achieve the ambitious UN's Sustainable Development Goals (UN, 2015). There is an obvious link to most of the 17 overarching goals (UNDP, 2015). However, the real challenge is to integrate science and technology into holistic solutions that demand a united political, financial, cultural approach which is not easy to achieve.

While there is an element of "idealism" in both the goals and some of the reports showing how STI can contribute, it is not a reason for pessimism but rather for challenging decision makers with science-based evidence (including social and political science evidence). It has to be acknowledged also that while science itself is neutral, its application can lead to both positive and negative outcomes so checks and balances and the ethics of scientific progress must be an integral element of appraisal. It is also true that the words used to describe sustainability can be interpreted in different ways. For example in advanced countries the concept of a sustainable lifestyle can be interpreted as a continuation of consuming rare resources at the current level whereas the reality is that these resources are finite and if all the world's population consumed at the same rate then this would lead to a rapidly unsustainable future.

The future is in our hands unless we ignore the evidence. The current reality is that demographic trends are expected to increase energy consumption by 45 %, water consumption by 30 % and food consumption by 50 % by 2030. We are facing unsustainable trends that risks to worsen climate change impacts, water scarcity and the loss of biodiversity. Moreover, there are two disruptive factors that can distort the system. First climate change which means the world laboratory may not be the same in the future. This means we have to extrapolate scenarios possibly to the point where there are discontinuities that are difficult to model. The second is micro politics which are unpredictable and often violent in nature. It is unrealistic, though sad, to think wars or human violation will not take place over resources or long held feuds. The possible impact of both these needs investment not only in measures to alleviate their impact but also in whole earth modelling, scenario simulations at a sufficient degree of granulation that are difficult to model or to imagine. These will require new sensors, observation systems, data collection and handling, and massive computing power which are open and accountable to the public.

More broadly, science and technology must be oriented towards solutions, solving real-world problems. This is also in the interest of innovators. Estimates vary but all acknowledge that there are huge innovation opportunities in moving towards a sustainable world. In the "New Climate Economy's" 2015 report "Seizing the Opportunity" it "examines three key drivers of change: efficiency of resource use, infrastructure investment, and innovation. All three offer potential for both improving growth and reducing climate risk. Progress will be especially important in three key socio-economic systems that underpin a large share of the world's economic activity and greenhouse gas (GHG) emissions: cities, land use, and energy. Credible and consistent policies are needed in each, taking into account the unique circumstances, varying capacities and differing needs of countries at different levels of development." The report estimates that around US$90 trillion is likely to be invested in cities, land use and energy creating sustainable jobs.

It is also important to encourage the development of the collaborative economy, sometimes called the sharing economy, which not only provides new opportunities for citizens and innovative entrepreneurs but also generates resource efficiency, circular economy and environmental protection. The EU must offer the right entrepreneurial environment to host and develop new collaborative economy ventures, backing up systemic innovation for sustainable cities and communities. The coming ten years must be the decade for solutions.

3.2.2. GLOBAL CONSENSUS ON SOCIETAL CHALLENGES

The year 2015 was a milestone for humanity, a year when the global community agreed on a common agenda for a more sustainable world by 2030. Key decisions were taken at global level which will reshape not only climate and development policy, but also guide private and public investment in R&I. Not only the Paris Agreement was reached at UNFCCC COP21, but also the UN Sustainable Development Summit set new sustainable development goals – at "2030 Agenda for Sustainable Development". The 3rd International Conference on Financing for Development, held in Addis Ababa, adopted the "Addis Ababa Action Agenda" (AAAA), launching the "Total Official Support for Sustainable Development (TOSSD)" which represents an option to increase transparency and to adapt the statistical system, reflecting at ODA the effort of public sector in catalysing the private sector investment on development and cooperation.

The "2030 Agenda for Development" established a set of goals (17) to end poverty, protect the planet, and ensure prosperity for all as part of a new sustainable development agenda. Each goal has specific targets to be achieved over the next 15 years.

The Paris Agreement, reached at UNFCCC COP21, sets out a global action plan to put the world on track to avoid dangerous climate change by limiting global warming to well below 2°C. The Paris Agreement opened for signature on April 22, 2016, and enters into force when 55 countries representing at least 55% of GHG emission have formally joined it. The process was expected to be completed in 2020. Remarkably, the PA entered into force already on Oct 5, 2016, since 100 countries have deposited their ratification accounting for 69.48% of the global GHG emission and the PA went into force 30 days later, i.e. Nov 4, 2016. Governments agreed on:

- A long-term goal of keeping the increase in global average temperature to well below 2°C above pre-industrial levels;
- To aim to limit the increase to 1.5°C, since this would significantly reduce risks and the impacts of climate change;
- On the need for global emissions to peak as soon as possible, recognising that this will take longer for developing countries;
- To undertake rapid reductions thereafter in accordance with the best available science.
- Come together every 5 years to set more ambitious targets as required by science (before and during the

ASPIRATION: A prosperous Africa based on inclusive growth and sustainable development

We are determined to eradicate poverty in one generation and build shared prosperity through social and economic transformation of the continent.

We aspire that by 2063, Africa shall be a prosperous continent, with the means and resources to drive its own development, with sustainable and long-term stewardship of its resources and where:

African people have a high standard of living, and quality of life, sound health and well-being;

- Well educated and skilled citizens, underpinned by science, technology and innovation for a knowledge society is the norm and no child misses school due to poverty or any form of discrimination;
- Cities and other settlements are hubs of cultural and economic activities, with modernized infrastructure, and people have access to affordable and decent housing including housing finance together with all the basic necessities of life such as, water, sanitation, energy, public transport and ICT;
- Economies are structurally transformed to create shared growth, decent jobs and economic opportunities for all;
- Modern agriculture for increased production, productivity and value addition contributes to farmer and national prosperity and Africa's collective food security; and
- Africa's unique natural endowments, its environment and ecosystems, including its wildlife and wild lands are healthy, valued and protected, with climate resilient economies and communities.

By 2063, African countries will be amongst the best performers in global quality of life measures. This will be attained through strategies of inclusive growth, job creation, increasing agricultural production; investments in science, technology, research and innovation; gender equality, youth empowerment and the provision of basic services including health, nutrition, education, shelter, water and sanitation.

Paris conference, countries submitted comprehensive national climate action plans; these are not yet enough to keep global warming below 2°C, but the agreement traces the way to achieving this target).

- Strengthen societies' ability to deal with the impacts of climate change;
- Provide continued and enhanced international support for adaptation to developing countries.
- The EU and other developed countries will continue to support climate action to reduce emissions and build resilience to climate change impacts in developing countries.

As shown in section 3.2.4., the EU has taken the lead on research and innovation on climate change. At the same time, according to relevant and consistent economic assessment, addressing climate change is not only urgent but it is also manageable and it can be cost-effective.

Both the "Stern Review" in 2006 and, more recently, the "New Climate Economy Commission", chaired by former Mexican President Filipe Calderon, concluded that "countries at all levels of income now have the opportunity to build lasting economic growth at the same time as reducing the immense risks of climate change".

Addressing climate change, energy security, clean energy access and sustainable development, not only requires dramatic change on science and innovation but it also offers significant environmental, societal and economical advantages for does that take the lead. The new climate, energy and sustainable development ambitious global framework, agreed in 2015, offers EU a unique opportunity to boost research and innovation on climate, energy and clean technologies.

Dealing with climate change and sustainable development goals requires a vision that goes beyond the traditional political time and spatial horizon. Climate impacts are not directly linked to the place where pollution is generated. It affects all nations, though not all equally. The poorest and most vulnerable are suffering most from a problem they did least to cause. And it is also a matter of intergenerational solidarity – action now to protect the future. Therefore, there is a need for leadership and responsibility from politicians to see beyond their vote horizon and embrace some sort of "oath" such as the Hippocratic Oath of medical doctors so that politicians can be held to account on delivering a sustainable world. This might be wishful thinking given the diversity of opinion but nevertheless worth the EU or UN initiating.

In an Open World, new actors are able to enter the debate and be drivers of change. Many of these actors are situated in the rising African continent.

3.2.3. THE EU VALUE ADDED COMES FROM LONG-TERM AND SYSTEMIC FRAMEWORKS

Over the last two years, the EU has launched several more broad and systemic policy "packages". They were complemented with a longer-term policy vision, which in the best cases sets concrete targets sending signals to the market on long-term stability and orientation. This was the case of the EU 2030 Framework for climate and energy, including EU-wide targets and policy objectives for the period between 2020 and 2030. The targets aim to help the EU achieve a more competitive, secure and sustainable energy system and to meet its long-term 2050 greenhouse gas reductions target. The strategy sends a strong signal to the market, encouraging private investment in new pipelines, electricity networks, and low-carbon technology. EU agreed on four targets for 2030:

- A 40 % cut in greenhouse gas emissions compared to 1990 levels
- At least a 27 % share of renewable energy consumption
- At least 27 % energy savings compared with the business-as-usual scenario
- 10 % electricity interconnections by 2020 and 15 % by 2030.

Furthermore, EU as agreed on a new set of reforms to meet these targets:

- A reformed EU emissions trading scheme (ETS)
- New indicators for the competitiveness and security of the energy system, such as price differences with major trading partners, diversification of supply, and interconnection capacity between EU countries
- A new governance system based on national plans for competitive, secure, and sustainable energy.

A clear illustration of a systemic push, where research and innovation is included as problem-solver in a larger legal and financial framework, is the EU Energy Union strategy, adopted by the EU in 2015 and implemented in 2016 through a comprehensive package of legal reforms and investment. It has five mutually-reinforcing and closely interrelated dimensions designed to bring greater energy security, sustainability and competitiveness: Energy security, solidarity and trust; A fully integrated European energy market; Energy efficiency contributing to moderation of demand; Decarbonising the economy; and Research, Innovation and Competitiveness.

A well-functioning internal energy market is the central instrument of the Energy Union and of the EU's competitiveness and energy security. The conclusion of the internal energy market will require strong emphasis on the deployment of interconnections, in order to achieve cost-effectiveness decarbonisation. The Energy Union also requires developments in the external dimension of the EU's energy policy to foster the diversification of energy routes and suppliers.

Renewable-based electrical mobility can deliver a significant impulse to decarbonisation and to energy security, whilst also contributing to better local air quality: in this context, an EU-wide policy for this sector would be welcome. Research and Innovation is essential to enhance Europe's energy security, reduce primary energy demand, and increase competitiveness of energy and climate technologies.

A second comprehensive and long-term initiative with potential for systemic innovation is the EU Circular Economy package, presented in 2015. It outline that waste prevention, eco-design, re-use and similar measures bring net savings of € 600 billion, or 8 % of annual turnover, for businesses in the EU, while reducing total annual greenhouse gas emissions by 2-4 %. Key actions of the EU Circular Economy Package include:

new targets for recycling; funding of over € 650 million under Horizon 2020 and € 5.5 billion under the structural funds; measures and targets on eco-design, secondary raw materials, plastics and water reuse.

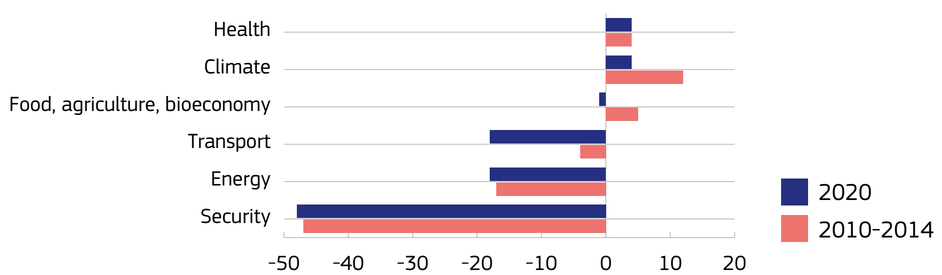
3.2.4. EU'S STRENGTHS IN ADDRESSING GLOBAL SOCIETAL CHALLENGES

As shown in the previous sections the fight against climate change and efforts for sustainable development are central parts of the UN Sustainable Development Goals from 2015. These are also at the heart of the COP21 agreement in Paris addressing climate change. These societal challenges cannot be achieved without science and technologies. Radical innovations must be coupled with the full roll-out of existing knowledge and technologies. The use of new technological solutions has to be implemented in an integrated and systemic way, where technologies are part of a wide range of policy instruments.[101]

In some areas, the EU has a strong position to take the global lead; in other areas of science and technology, other regions in the world are showing the way. International cooperation is crucial in both cases. This section presents some statistical evidence on EU's competitive advantages in science and technologies in areas relevant for Sustainable Development (Reiss et Al, 2016).[102]

The specialisation of the science system can be measured by the "Revealed Literature Advantage" (RLA), with extrapolations up to the year 2020.[103] According to this indicator, the EU has a clear comparative advantage compared to other world research centres in science addressing climate change, health, food and the bioeconomy. This strong position is expected to be reinforced in the coming years. However, in the field of energy, EU research does not hold a comparative advantage.

Figure OW.1: EU's scientific specialisation in 2010-2014, and extrapolation for 2020



Source: Fraunhofer ISI, Study on EU Positioning: An Analysis of the International Positioning of the EU Using Revealed Comparative Advantages and the Control of Key Technologies, 2016 .

[101]) *See OECD study: https://www.innovationpolicyplatform.org/sites/default/files/general/SYSTEMINNOVATION_FINALREPORT.pdf*

[102]) *Study commissioned by the European Commission, DG Research and Innovation, in cooperation with the RISE high-level expert group.*

[103]) *The scientific publications within the dataset are collected from Thomson Reuter's Web of Science (WoS) database. Data is extracted from the Science Citation Index (SCI), the Science Citation Index Expanded (SCIE) and the Social Science Citation Index (SSCI). The classification by fields is based on the existing list of 27 scientific disciplines with the subject categories provided by Thomson Reuters. Combinations of subject categories and keyword searches are applied to KETs and SGCs.*

The situation is slightly different with respect to technology development. The specialisation in technology development is measured by the Revealed Technological Advantage (RTA), based on patent applications.[104] Technology production is more closely related to corporate R&I investments by business enterprises, although patents are also filed by universities and other public research organisations.

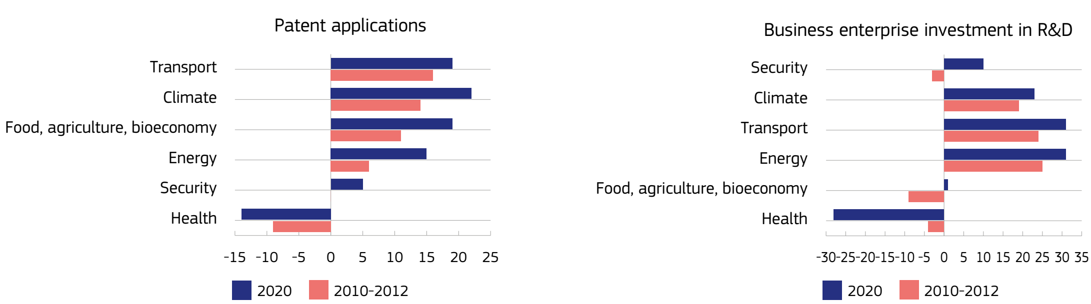
The EU holds a world leading position in technology development in many areas relevant for addressing a Sustainable Development, with the exception of technologies for health. This competitive position of the EU is foreseen to expand in view of 2020. Figure OW.2 presents EU's comparative advantage in both patent applications and business investment in R&D.

The EU's competitive position in these technology fields for Sustainable Development cannot be fully assessed without the dynamics of "Key Enabling Technologies" (KETs).[105] These are technologies which are not forcefully focused on solving a societal challenge, but being pervasive and applicable in most technology areas, they have a strong potential of advancing radical technological challenges also in favour of Sustainable Development.

Figure OW.3 illustrates the correlation and impact of various KETs on global societal challenges.[106] The Key Enabling Technologies most closely correlated with technology solutions for climate and energy are microelectronics, electronic components, and advanced materials. KETs on the future of internet and biotechnologies are also relevant for the two societal challenges of climate and energy. Similarly, biotechnologies and advanced materials have potential to contribute to breakthroughs for food solutions. Advanced digital technologies have potential to enable radical change for most areas of societal challenges.

However, compared to other major technology producers in the world, the EU has not developed any strong competitive edge in these Key Enabling Technologies, with the exception of advanced manufacturing technologies and space-related technologies. For the KETs more closely related to global societal challenges in food, health, climate, or energy, the EU as a whole has a lower technology specialisation than the US, or Asian countries.

Figure OW.2: Comparative advantage in technologies for societal challenges, 2009-2013; extrapolation for 2020



Source: Fraunhofer ISI, Study on EU Positioning: An Analysis of the International Positioning of the EU Using Revealed Comparative Advantages and the Control of Key Technologies, 2016.

[104]) The patent data is extracted from the EPO Worldwide Patent Statistical Database (PATSTAT), which covers patent information from more than 80 patent offices worldwide. All the patents used for the analysis were counted according to their year of worldwide first filing, what is commonly called the priority year. All filings at the World Intellectual Property Organisation (WIPO) under the Patent Cooperation Treaty (PCT) and all direct filings at the European Patent Office (EPO) without precursor PCT filing are counted. This excludes double counting of transferred PCT filings to the EPO.

[105]) The definitions of KETs are based on the KETs Observatory (IDEA Consult et al. 2015). In the case of societal grand challenges, the classification is elaborated by Frauenhofer ISI within a project for the JRC-IPTS (Collection and analysis of private R&D investment and patent data in different sectors, thematic areas and societal challenges).

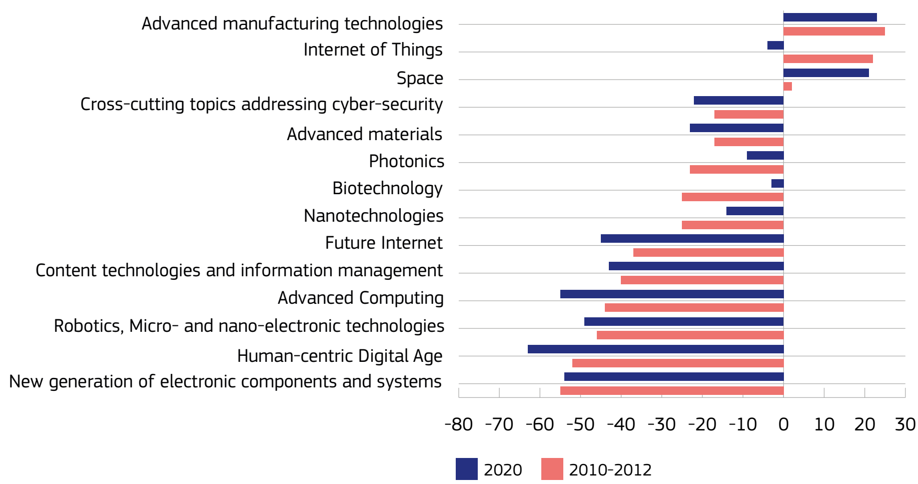
[106]) The heatmap shows the share of patents in each societal grand challenge that can also be assigned to one of the KETs.

Figure OW.3: Heat map of links between KETs and SGCs based on shares within SGCs

	HEALTH	FOOD	ENERGY	TRANSPORT	CLIMATE	SECURITY
Biotechnology	2.8%	13.1%	2.4%	3.2%	4.3%	4.5%
Nanotechnologies	0.6%	0.8%	1.2%	0.1%	0.6%	0.6%
Microelectronics	0.2%	1.3%	12.1%	0.7%	0.4%	1.0%
Photonics	0.6%	1.0%	3.5%	1.0%	0.5%	2.8%
Advanced materials	1.1%	7.9%	4.6%	1.8%	9.3%	0.6%
AMT	0.9%	1.1%	2.4%	5.5%	2.2%	3.9%
Components	0.2%	0.2%	12.0%	0.6%	0.4%	0.8%
Advanced computing	3.5%	1.1%	4.3%	16.4%	0.4%	26.9%
Future Internet	0.8%	0.5%	6.3%	4.8%	0.1%	17.9%
Content technologies	0.3%	0.1%	0.3%	10.2%	0.0%	1.9%
Cyber security	0.0%	0.0%	0.1%	0.4%	0.0%	15.4%
IoT	0.0%	0.0%	0.1%	0.1%	0.0%	0.1%
Digital age	0.9%	0.1%	0.8%	6.0%	0.1%	8.5%
Space	0.0%	0.1%	0.3%	2.8%	0.0%	0.5%
Total overlap	12.1%	27.3%	50.5%	53.6%	18.3%	85.5%

Source: Fraunhofer ISI, Study on EU Positioning: An Analysis of the International Positioning of the EU Using Revealed Comparative Advantages and the Control of Key Technologies, 2016.

Figure OW.4: EU comparative advantage in KETs in 2009-2013; extrapolation 2020



Source: Fraunhofer ISI, Study on EU Positioning: An Analysis of the International Positioning of the EU Using Revealed Comparative Advantages and the Control of Key Technologies, 2016.

This shows not only a need to upgrade the efforts in several Key Enabling Technologies but also that the EU cannot take up the challenge of Sustainable Development alone. It needs a reinforced international cooperation in science and technology development with the other leading S&T countries in the world. This is the case in research as well as for technology development. In the latter case, it is also important to consider in particular the Key Enabling Technologies closely related to energy, food, health and climate.

3.3 SCIENCE DIPLOMACY

Ivo Slaus, Helen Wallace, Kerstin Cuhls and Marga Gual Soler

"Science diplomacy and international scientific cooperation are no longer interesting additions, at the margins of our core policy. On the contrary, they are today a mandatory and critical part of our day-to-day work. To achieve a new chapter of even higher scientific excellence in Europe, and to achieve a more effective engagement in addressing global challenges, we need science to bring Order to Disorder."

Carlos Moedas, ERC Conference 27 October 2016[107]

3.3.1. INTRODUCTION

The global environment in which the EU operates is constantly evolving. Recent developments demonstrate how dynamically the strategic and geopolitical contexts are shifting. These represent intricate challenges but also opportunities for Europe to develop analytic and practical tools to better anticipate and address challenges in key regions and build more robust, proactive and reactive capacities. In such turbulent times, greater emphasis should be placed on fostering new types of actions and partnerships that strengthen the position of Europe on the global scene, including improving the coordination between EU Member States and broadening its means of external action, but also increasing our understanding of Europe in a global context.

To this end, Commissioner Carlos Moedas made science diplomacy a top priority in the Commission's agenda (Moedas, 2016).[108] There is no uncontested definition of science diplomacy, but there is a general agreement that three varieties of science diplomacy can be distinguished, first defined by the American Association for the Advancement of Science and the Royal Society (2010):

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107) https://ec.europa.eu/commission/2014-2019/moedas/announcements/science-diplomacy-driver-excellence_en

108) COM(2012) 497 specifically states that 'Science diplomacy will use international cooperation in research and innovation as an instrument of soft power and a mechanism for improving relations with key countries and regions. Good international relations may, in turn, facilitate effective cooperation in research and innovation.'

I. Diplomacy for Science promotes international scientific collaboration, using the classic tools of diplomacy to support the scientific and technological community.

II. Science in Diplomacy occurs when scientists provide input or advice to foreign policy and decision-making, including global governance.

III. Science for Diplomacy uses science as a tool to build and improve relations between nations, whether to address shared problems or to mitigate tensions.

Science diplomacy is globally becoming of crucial relevance at a time of major crises, but it is still scarcely known and perhaps not optimally used. With its high level of scientific excellence, the EU should be able to mobilise its scientific potential as a main means of action within its foreign and security policies as well as for the solution of global problems

This chapter sets out the background to science diplomacy and discusses ways in which a more ambitious approach and concrete strategy might be developed within the EU. This could include strengthening research and innovation activities to promote the position of Europe on the global scene, to attract international partners to Horizon 2020, to leverage research and innovation exchanges that promote broader dialogue and to address shared challenges, with a reinforced European research and innovation presence in strategic partner countries and regions.

3.3.2. BACKGROUND AND HISTORY OF SCIENCE DIPLOMACY

Diplomacy is "the established method of influencing the decision and behaviour of foreign governments and peoples through dialogue, negotiation and other measures short of war or violence"; διπλω – μα: official document conferring a privilege, composed of two words: diplo: folded in two and ma – meaning an object.

Diplomacy changed after World War I and particularly after WWII with the establishment of numerous international organizations: the League of Nations, the International Labour Organisation (ILO), and the United Nations (UN), and even more toward the end of the 20th century with the establishment of intergovernmental organizations, such as the IPCC, and the creation of several supra-national organizations: the European Community, later the EU, OPEC, Organization of African Unity, Arab League, ASEAN, and the Organization of American States.

Sovereign states and the entire world became faced with totally different threats and problems: destruction of the environment, climate change, large scale terrorism, international organized crime, drug and human trafficking and now chaotic and large scale migration – none of these issues can be solved just within one country, and all of them require international cooperation. Several subfields of diplomacy emerged, e.g.: public diplomacy, cultural diplomacy and science diplomacy.

Contrary to military and economic power, science is infinite and it increases when it is shared. Science has always been international, and constitutes an excellent basis for win-win games, therefore it should be placed "at the heart of progressive international agendas (Nye, 1990)" The 21st century requires that science, policy and politics should be more integrated. "The tools, techniques and tactics of foreign policy need to adapt to a world of increasing scientific and technical competencies (Royal Society and AAAS, 2010)."

Science diplomacy is a new concept describing an old practice with a long history. We can distinguish three strands of development of science diplomacy:

1. Establishing formal connections between scientific research and international relations, including science for global governance;

2. International scientific collaboration facilitated by diplomacy;

3. 'Track II' diplomacy in addition to 'Track I' which involves official government-to-government diplomacy, where unofficial non-governmental but informed citizens interact with other citizens.

The first strand was visible already in 1957, when NATO introduced a programme for science. From 2006 it became the Science for Peace and Security Program. The US National Academy of Sciences and the Soviet Academy of Sciences ran throughout the 80's parallel Committees on International Security and Arms Control (CISAC). The UN Conference on Trade and Development (UNCTAD) decided in 2001 to establish science diplomacy to assist in multilateral negotiations. Since 2005, the national academies of G8+5 countries have met annually with the G8 to produce joint statements. The European Academies Science Advisory Council (EASAC) has provided regular advice to the European Commission since 2006. In 2007 Japan formulated an explicit policy on science diplomacy. In 2008 the American Association for the Advancement of Science (AAAS) established its Centre for Science Diplomacy and soon after in 2012 launched a policy journal, Science & Diplomacy. Currently the UN Science Advisory Board (SAB) provides science advice to the UN.

Almost immediately after WWII scientists started planning international collaborations including scientists from countries recently at war. The European Organisation for Nuclear Research (CERN) was established in 1954, under the auspices of UNESCO. At present CERN has 22 member countries, with other associates, and includes scientists from over 600 institutions around the world. At the initiative of Pierre Auger and Eduardo Amaldi, ten European countries founded the European Space Research Organization in 1962 – now European Space Agency (ESA). Following the CERN model, the Synchrotron-light for Experimental Studies and Application in the Middle East (SESAME) was founded in Jordan in 2002 now including Jordan, Israel, Palestinian Authority, Egypt, Iran, Turkey, Bahrain and Pakistan, and the USA, UK, Japan, Germany, Italy and several other countries, and the EU as observers.

Meanwhile, another form of diplomacy has developed on a different level: researcher-to- researcher contacts have also proliferated globally. International networks through science: conferences, research consortia and social media provide a completely different forum for transnational science – a level of direct exchange and personal interaction disregarding borders and etiquette. To be effective, Track II diplomacy must remain credible and influential and official Track I diplomacy must recognize the role of Track II efforts. To this end, it is essential that there is a fluent dialogue between academic and policy- and decision-making circles.

Today, many countries – large (e.g. the USA, the UK, France, Spain, Germany, Japan) and small, e.g. New Zealand (Gluckman, 2012) – are successfully employing science diplomacy in the conduct of international relations, involving a variety of stakeholders and non-state actors including universities, civil society, international organizations, business and trade unions.

New Zealand (Gluckman and Goldson, 2012) used science to make the case for the country to serve a term on the UN Security Council in 2015-6 and more broadly it has drawn on its science base to underpin its chances of strengthening commercial exports and trade. Canada (Bernstein, 2013) has deployed science diplomacy as part of its basis for global influence as well as for projecting Canadian values. Japan (Sunami et Al., 2013) conducted a systematic review and analysis of science diplomacy, developing country profiles to develop its strategy. It deploys science diplomacy to project S&T leadership and to strengthen regional relationships. It is stated that even the Olympic and Paralympic games 2020 are regarded as occasions for science diplomacy (Ogasawara, 2015). South Africa (Pandor, 2012) has developed science diplomacy to rebuild relationships with partner countries after apartheid and to promote regional development in Africa. The EU can learn from these examples in developing its own targeted science diplomacy.

3.3.3. SCOPE AND LIMITS OF SCIENCE DIPLOMACY

Joseph S. Nye distinguishes two approaches in conducting international relations: hard power and soft power, and defines “soft power” as “the ability to persuade through culture, values and ideas, as opposed to hard power” which conquers or coerces through military might” (Nye, 1990). Concept and methods outlined by Nye are elements of what we now call science diplomacy. However, we must take into account the following considerations:

a) Conceptualising science diplomacy is complex and multi-layered. This causes a number of problems. First, there is a risk of overstretching the concept. If seen to broadly, the concept applies to pretty much any practice that involves both science and international actions. Consequently, if everything that involves an international dimension and science is categorised as science diplomacy, then the term risks losing its meaning. In order to avoid a too broad approach to science diplomacy, one should limit the use of the concept to the policies and practices that involve both S&T policy and foreign policy.

b) "In all forms of science diplomacy it is important to be clear when science ends and politics begins." (Slaus, 2016). This is neither straightforward nor simple. First, science is not a repository of final, eternal truth, but constantly changes. Most societal challenges are multi-, inter- and even trans-disciplinary, whereas science has latterly evolved as discipline focused. Almost all problems now facing humankind require integrative, multidisciplinary and holistic studies (see the concepts of foresight). Second, development of science is to some extent culture based and culture influenced, and scientists have become an international labour-force belonging to a range of countries. Scientists are people and science is not a socially and culturally neutral process.

c) Science, policy and politics evolve on very different time scales. For instance, though the Geneva Convention banned the use of chemical weapons in 1925, negotiations for the treaty to ban production and stockpiling started in the 80's, and entered into force only in 1997.

d) Any scientific input to foreign policy implies that both parties – those giving advice and those receiving the advice – have an ability to communicate and understand the message. That implies that scientists are able to "translate" scientific facts, technological information, foresight exercises, innovation aspects and implications into information that is understandable to the public at large and to decision-makers and policy-makers.

Science diplomacy rests on several foundations (Flink and Schreiterer, 2010). National scientific resources and quality are enriched by attracting the inflow of people and knowledge from elsewhere. International collaboration is recognised as adding value to what can be achieved at the national level. . The incorporation of scientific achievements into relations with other countries provides opportunities for influence.

3.3.4. SCIENCE DIPLOMACY IN THE EU

The EU has sought to develop an active policy for international cooperation in science and technology over the past decades. A key step was taken in 2008, when the European Commission adopted a 'Strategic European Framework for International Science and technology Cooperation' and established a European 'Strategic Forum for International S&T Cooperation' (SFIC) with the objective "to facilitate (...) the international dimension of ERA"[109]. This seeks, on the one hand, to increase the opportunities for researchers to work together across national boundaries and with researchers elsewhere in the world, and, on the other hand, aims at drawing on scientific assets in support of other external policy objectives[110].

As part of the development of Horizon 2020, the Commission issued in 2012 a communication on '*Enhancing and focusing EU international cooperation in research and innovation: a strategic approach*'. This aims at: making the EU even more attractive in terms of its research and innovation excellence; strengthening its capacity to address global societal challenges; and underpinning the Union's external policies (European Commission, 2012). This presumes the exploitation of cooperation in research and innovation to deploy soft power and to improve relations with third countries. It also implies a need for much closer coordination across the services of the EU that are responsible for its external policies across the range. A subsequent communication (European Commission, 2014), stressed the case for additional steps to promote the external dimension of research and innovation policy, with a passing mention of the term 'science diplomacy'. Carlos Moedas, the EU Commissioner for Research, Science and Innovation, took this approach further in his speech at the European Institute in Washington on 1 June 2015, when he argued for "*science diplomacy to play a leading role in our global outreach for its uniting power*", (Moedas, 2015) comparing science diplomacy to a torch that can "*light the way, where other kinds of politics and diplomacy have failed*".

The EU is represented through some 140 EU Delegations and Offices around the world. The creation of the European External Action Service (EEAS), introduced by the Treaty of Lisbon and entered into force on 1 December 2009, aims at making the EU's external action more coherent and efficient. The nature of the challenges of the 21st century – rooted in science and driven by technology – presents an opportunity to increase the European Union's influence

[109]) *http://www.consilium.europa.eu/policies/era/sfic*

[110]) *See the INCO monitoring report (2012) Overview of international science, technology and innovation cooperation between Member States and countries outside the EU and the development of a future monitoring mechanism, p. 11*

in the world using science diplomacy as an instrument for European soft power and as a mechanism for improving and strengthening relations between the EU and the rest of the world. But this poses three major challenges: (i) how to carve out a specific role for the EU that complements the Science Diplomacy policies of its Member States; (ii) how to draw together the scientific resources of the EU in support of the EU's various externally facing policies, such as trade or development; and (iii) how to integrate that role in the overall EU's Global Strategy for Foreign and Security Policy driven by EEAS.

3.3.4.1. SCIENCE IN DIPLOMACY

A first strand of action concerns the need to build capacity to give and receive scientific advice across borders and actors and more broadly to employ science diplomacy as a useful instrument in shaping national and global policies. Scientific exchanges create opportunities to raise awareness among the scientific community in third countries on EU values, visions and priorities. Educating for Science Diplomacy is key to develop this capacity (Turekian and Wang, 2014).

There are outstanding higher education institutions in EU Member States and the AAAS Centre for Science Diplomacy in Washington DC that is now organizing annual science diplomacy training workshops with The World Academy of Sciences (TWAS) in Trieste, Italy[111]. They all can serve as a model and/or for twinning with emerging mechanisms described above. The Joint JRC-IIASA Summer School on Evidence and Policy[112] can also serve as a model.

A second strand of action for science in diplomacy is the role of scientific advice and partnerships in addressing global challenges requiring scientific and diplomatic coordination, such as climate change, and the governance of international spaces, e.g. outer space, deep-sea, the Arctic and Antarctica. These issues cannot be managed through conventional models of governance and diplomacy, and will require flexible international cooperation, informed by scientific evidence and underpinned by practical scientific partnerships.

A third strand of action relates to the ability of science to anticipate risks and handle uncertainties and instabilities much better than politics[113]. EASAC and IAMP warned of a global threat posed by antimicrobial resistance. "The Sendai Framework of the UN Office for Disaster Relief Reduction highlighted the need for integrated and holistic scientific advice during crises and emergencies. Too often, science advice has been siloed within individual agencies" (Gluckman, 2016), while government needs more integrated and planned approaches. Risk anticipation and management of uncertainties, instabilities and singularities make scientific research valuable in endeavours to link the legislative-executive-judicial branches of government and scientific communities.

There are different institutions providing insides into opportunities in science and technology as well as general risks. Many studies under different labels (Foresight, Horizon scanning, Risk Assessment) are available but often remain at the laboratory level (Cuhls, 2015). There are competences at the EU level – especially with the EPSC (the European Political Strategy Centre), Directorate General Research and Innovation (DG RTD), DG Communications Networks, Content and Technology (DG CNECT), the Joint Research Centres (JRC) and potentially as an umbrella organisation in the European Strategy and Policy Analysis System (ESPAS). In parallel, the member states have their own institutions, which could better be combined with the EU level even though some informal networks exist. Their warning function is still rather weak – because they often lack an entrance point into the system and persons who have the role to promote opportunities or warn in case of risks are often not directly linked to decision-making process.

Science diplomacy, as internal science diplomacy of the track I type, can play a role in connecting to the relevant information broker at a higher level[114], but also the scientists involved in the different studies can themselves act as internal and external science diplomats of the track II type. The existing institutions need more attention and an extended mandate for providing outlooks, which may not always be as firmly

111) http://twas.org/opportunity/aaas-twas-course-science-diplomacy-2016

112) http://www.iiasa.ac.at/web/home/about/events/150902-JRC-IIASA-Summer-School.html

113) Paul Berkman: Science as an early warning system, Science as a determinant of public policy agendas and an element of international institutions, Science as an instrument for Earth system monitoring and assessment or even as an essential gauge of changes over time and space. See http://www.academies.fi/en/science-diplomacy-for-the-common-good/

114) First internal connections are the Foresight Correspondent Network in the European Commission.

evidence-based as pure scientific/ empirical work, but can demonstrate different assumptions, alternatives and options for the future.

3.3.4.2. SCIENCE FOR DIPLOMACY

"Scientific values of rationality, transparency and universality are the same the world over. They can help to underpin good governance and build trust among governments."[115] An excellent example is the Iran nuclear deal made possible through discussions involving two physicists that at one time worked at MIT.

Our contemporary world reveals numerous points of danger and stress. There are social stresses such as demography augmented by migration, due to both environmental and political problems. There are failed states, frozen conflicts, confrontation between interests of major world powers, or the development and use of technologies of mass destruction and use of technologies by organized crime. Solutions to these issues require a variety of science diplomacy methods and actions alongside political engagement: these include bilateral and/or multilateral scientific cooperation involving affected countries and some of the most advanced countries using Open science and Open innovation mechanisms, especially to overcome mistrust.

International scientific cooperation provides access to the world's best minds, as well as infrastructure and research facilities, as means to increase the quality of EU research. But perhaps most importantly, it promotes out-of-the-box thinking, problem-solving, and people-to-people connections among scientists from different countries, ideologies, cultural backgrounds and political views. An excellent example is the current operation of four major accelerators at CERN. Large activities around these detectors include thousands of scientists, engineers, technical and administrative personnel. SESAME is modelled on CERN: as CERN connected countries that had just come out of a major world war, SESAME connects countries that were historically in conflict and continue to be in conflict today. Through "spaces", in which open thoughts can be facilitated and exchanged, this leads to completely new approaches and even new fields of thought for the future.

Through the 2016 Work Programme of Horizon 2020, the EU seeks to strengthen the position of Europe as a global actor by reinforcing the presence of European research and innovation in selected international partner countries and regions. It is currently selecting proposals for Centres of European Research and Innovation in leading countries and regions, targeting topics focused on issues in the immediate EU neighbourhood regions (both South and East), such as migration and radicalisation trends, as well as broadening the geographical coverage of the first Work Programme by focusing on Asia-Pacific, Central Asia, and China.

Each individual EU Member State has a number of local and regional issues where science diplomacy can and should be useful. For instance, several Member States were republics within the USSR. Despite tensions and prejudices, there is an enormous wealth of linkages through generations living together and particularly important many scientists from these new sovereign states lived and worked in what is today the Russian Federation and some have established and still maintain excellent relationships. The World Academy of Art and Science (WAAS) established in 2005 its South-East European Division (SEED) encompassing all countries from Italy to Turkey. SEED is an example of excellent joint work among scientists, scholars and politicians. States that emerged from former Yugoslavia would benefit from scientific collaboration, mutual as well as multilateral involving other European countries.

Better coordination between the European Commission and EEAS will enable more active exploitation of the science base assets of EU soft power in relation to other countries and other regions of the world, to some extent emulating what is already being done by some EU member states.

3.3.4.3. DIPLOMACY FOR SCIENCE

Science diplomacy offers opportunities to spread EU values30, but it can also help improve the framework conditions for cooperating internationally in research and innovation in support of President Juncker's Priorities. The EC can and should act as a pioneer of S&T on the international stage by establishing strategic S&T bilateral agreements and high-level policy dialogues at the country and regional levels in the context of a Global Research Area.

115) https://www.aaas.org/sites/default/files/New_Frontiers.pdf

Mobility – From Brain Drain to Open Brain Mobility

Inner European Mobility – Brains at locations with impact

Good brains need a suitable environment for exchange, for gaining experiences and for evoking impact. The EU can foster this by remaining open and support exchange and mobility on different levels, virtual and physical. There is evidence that being mobile and open to the world has positive effects in science and on the innovative capacity. But being open needs further exploitation: to set plurinational teams with all their creativity, collaborative power and mutual learning in a suitable environment across countries needs support. Often, international collaboration in research and innovation is the result of a mobility experience[116].Virtual mobility partly substitutes physical mobility, but mainly short-term (50% versus 9% for long term mobility)[117]. Mobility does not only have an impact on the researcher's career (EU27), intangible effects like advanced research skills or better international contacts and networks are observed as well. Even measurable impacts like a higher number of patents or publications including a better quality of publications[119] or more international co-publications can be counted[120].

The most attractive countries for EU researchers are still the UK, France and Germany in Europe and the USA outside of Europe. The share of scientists and engineers in the total labour force (2013) in the EU is 4.1 per cent for male and 2.8 per cent for female with differences in the EU countries. The More2 survey shows an average difference in the international mobility of male and female researchers in the later years of their career (post-doc), less in the earlier years during their PhD[121]. The differences in mobility (women less mobile) are highest in Cyprus, Germany, Finland and Sweden.

Mobility towards Europe – absorptive capacity and integration needed

Within a Europe with a shrinking population in the long run, immigration of good brains and motivated people is a potential that needs further empowerment. Not only scientists, also good brains for other sectors are needed.

Among the permanent and non-permanent immigrants – including the refugees from crisis regions – are scientists, researchers, technicians. Integrating and keeping them in the European innovation system will thus create a win-win situation. Studies show that "…there appears to be no negative effect of immigration on native employment and wages" (Krause et Al., 2014), rather a positive net effect on regional income and an increase in the supply of different skills, knowledge and tasks evoked by the higher cultural diversity. Migrants tend to be more entrepreneurial, even in the high-tech sector, for example up to 25% of the start-ups in Tech City in London were founded by migrants Wadhwa et Al., 2012)[122]. It is not an easy task to integrate researchers of different cultures speaking different languages and having different educational backgrounds that are not equivalent to those in the EU. By being open to the world in this respect, the fruits of diversity and creativity can be harvested – and if the scientists or technical experts go back to their home country or to other places in the world they remain valuable contacts into businesses, organizations and even governments. They build up an international network that needs to be kept active. The Blue Card Directive[123] is a first attempt to gain brains actively and attract talent and knowledge to Europe. Science and Innovation vouchers would be another possibility to foster exchange.

116) Van Hoed, M (2015): Mobility of researchers Results from the MORE2 study, presentation at the KoWi Annual Conference, Berlin 2015; http://www.kowi.de/Portaldata/2/Resources/vortraege/buta27/2015-06-18-van_Hoed.pdf;. See also EUA membership consultation 2013: Internationalisation in European higher education: European policies, institutional strategies and EUA support; http://www.eua.be/Libraries/higher-education/EUA_International_Survey.pdf?sfvrsn=0

117) See MORE2 study

118) Van Hoed, M (2015): op cit

119) DG Research and Innovation – Unit for the Analysis and Monitoring of National Research Policies (2013) , Figure I-2-37, Science-Metrix (Canada) based on Scopus database and OECD: STI Scoreboard 2013.

120) Figures according to Eurostat, see European Commission: SHE Figures 2015; Brussels 2016; p. 46; DOI: 10.2777/744106

121) European Commission: SHE Figures 2015; Brussels 2016; p. 107; DOI: 10.2777/744106

122) See also The Tech London Advocates Blog (2013), 'Blanket migration laws threaten the thriving Tech City start-up scene', July 2013; in the US Silicon Valley, 44% of the key company founders are foreign born.

123) Directive 2009/50/EC of 25 May 2009 on the conditions of entry and residence of third-country nationals for the purposes of highly qualified employment, OJ L 155, 18.6.2009, pp. 17–29. The United Kingdom and Ireland did not «opt-in» to this Directive and are not bound by or subject to its application. See also European Agenda on Migration, http://ec.europa.eu/dgs/home-affairs/what-we-do/policies/european-agenda-migration/index_en.htm.

3.4 TOOLS FOR SCIENCE DIPLOMACY IN THE EU[124]

Ivo Slaus, Helen Wallace, Kerstin Cuhls and Marga Gual Soler

3.4.1. INTRODUCTION

Science Diplomacy is globally becoming a crucial issue at a time of major crises, but it is still scarcely known and perhaps not optimally used. Europe, in particular the EU, has a high level of scientific excellence and should therefore be able to mobilise its scientific potential as a main means of action within its external policies. The overall aim of this study is to present an evidence-based scanning of the most relevant Science Diplomacy policies, some best practices or tools existing within the EU Member States and in some other relevant countries. This is done through presenting an overview of the concept and relevant tools and practices as well as an explanation of the rationale and process required to set them up.

One of the challenges in defining an EU science diplomacy strategy is to consider the relationship between what is done at the level of the member states and what can be done at EU level. The sensible way forwards is: to build on the experiences of member states; to develop a more active European collective approach; and to seek to ensure that these complement each other. Specifically as regards the EU, a number of practical steps could and should be taken to enable the EU to develop a more active and more effective approach to science diplomacy. These would in turn help to strengthen the influence of the EU in the world and go further to mobilising its scientific assets in tackling global challenges, as identified in section 3.2. Suggestions for possible actions are set out in our concluding section 3.5. To be over-ambitious would be counter-productive; hence it could make sense to develop a specific geographical focus by putting a particular initial effort into science diplomacy vis-à-vis Africa where there are many opportunities for reinforcing scientific collaboration.

[124]) *Based on a study by Luk Van Langenhove of the United Nations University and Vrije Universiteit Brussel commissioned by DG RTD*

3.4.2. CLASSIFYING TOOLS FOR SCIENCE DIPLOMACY

The mapping exercise documented in the paragraphs below revealed that what is considered as implicit or explicit science diplomacy practices can take many forms. Such practices can emerge spontaneous, but most often they will be the result of deliberate policies and/or support schemes with an involvement of some governmental agencies. Based upon the collected cases, a classification scheme has been constructed that allows classifying the most important available governmental tools and instruments that can be used in promoting or supporting science diplomacy. The classification scheme involves three categories: strategic tools, operational tools and support tools.

A) *Strategic Tools*

Strategic tools for Science Diplomacy are policy documents that aim to give directions to what actors want to achieve and how to realise their policy goals. Here we are mainly talking about governmental communications that set out policies for Science Diplomacy. Such documents can contain general 'visions' of what a government aims to achieve or it can be more specific strategy declarations issued by the government or a governmental department, such as a Ministry of Science and Technology Policy or the Department of Foreign Affairs.

Moreover, in principle it is possible that such strategic documents also occur at the level of sub-national entities with governance responsibilities in either science and technology policy or foreign relations. And of course, semi-governmental institutions such as Research Foundations or Academies can issue strategic documents with a Science Diplomacy perspective as well.

B) *Operational Tools*

Operational tools for Science Diplomacy are policy instruments used to put Science Diplomacy into practice. They involve the allocations of specific resources as well as mechanisms on how to use them. There exist many different operational tools to put Science Diplomacy in action.

A first important category contains the bilateral or multilateral S&T cooperation agreements between two or more states. These can take the form of:

(i) Umbrella or framework agreements that promote scientific or technological cooperation, or

(ii) Specific agreements between two or more states or governmental agencies that cover topical points of collaborations.

Many of these agreements focus upon mobility schemes between the counties involved or upon joint projects. A special case of such agreements are the ones that foresee in the creation of joint international S&T institutions by two or more states.

A second category, dealing with 'science IN diplomacy' are the S&T advisory mechanisms at the level of states. These advice systems can take the form of a single advisor, an advisory council or high-level group. They can be installed at the level of the Prime Minister or be related to the department of Foreign Affairs or the Ministry for Science and Technology. In principle such bodies can also be institutionalized, as for instance a S&T office within a department of Foreign Affairs. In all cases the purpose is to inject scientific knowledge into state governance.

A third category are the S&T advisors attached to embassies where the objective is to assist the national diplomatic mission in establishing cooperation with the scientists of the country where the embassy is located.

Fourthly, there is the opening of national or regional research funding schemes to third party researchers. This can take the form of financial support of individual fellowships or staff exchange programmes, financial support for specific cross-border S&T cooperation programmes or joint calls for S&T projects issued by two or more states.

C) *Support tools*

Finally, there are so-called support tools for Science Diplomacy that aim to promote or facilitate Science Diplomacy activities. These tools include:

- Training activities regarding science diplomacy. Audiences can be either diplomats or scientists.
- Awareness building activities geared towards scientists or diplomats.
- Dialogue and consultation platforms.

Next to these supporting practices, governments can also set up or fund specific agencies that support the organisation of certain operational tools for Science Diplomacy.

The Spanish 'Ambassadors for Science' Shadowing Programme

A new scheme launched in 2016 at the Embassy of Spain in London 'Ambassadors for Science' aims to bring together scientists and diplomats in order to get both professionals from two different worlds closer and to allow them to experience each other's world. Whereas scientists shall receive introductory seminars about the Spanish diplomatic action, diplomats will receive basic notions about the performance of science at the global level, and how it is structured in both the Spanish and British national systems of Science and Technology. Scientists will also shadow diplomats on their daily routine to learn about the diplomatic activity. Conversely, diplomats shall visit scientists' job place to get an insight first-hand about the world of science, technology and research.[125]

[125]) *Read more at https://www.fecyt.es/en/info/ambassadors-science*

3.4.3. STRATEGIC TOOLS FOR SCIENCE DIPLOMACY AT NATIONAL LEVEL

The literature review and internet search revealed that it is not easy to find strategic documents at the level of EU Member States with regard to science diplomacy. This is certainly related to the fact that 'Science Diplomacy', contrary to for instance 'Cultural Diplomacy', is a relatively new concept and thus not yet widespread in national policy-making circles.

There are however exceptions of EU Member States that have some kind of national strategy documents for Science Diplomacy. Amongst them are France, Spain and Germany.

The Ministry of Foreign Affairs of France has since 2011 a strategic framework document, entitled "*Une diplomatie scientifique pour la France*". The strategy is organised around four axes: The defence of the French S&T interests, closely related to the French economic interests; the utilisation of S&T cooperation as diplomatic tool, in particular in the euro-Mediterranean space; the contribution of science to the understanding of global challenges; and the promotion of science for development as integral part of its public support to development.

The strategic document also situates the efforts in Science Diplomacy as part of the French cultural diplomacy and as a tool to strengthen France's influence in the world. In 2013, a new strategic report was published that has formalized its objectives and a plan of action that was jointly prepared by the Ministry of foreign affairs and the Ministry of Higher Education and Research. The report spells out how the two ministries closely work together to ensure the consistency of France's actions and aims to contribute to a reinforcement of the interactions between the French scientists and the French diplomatic network.

Spain published in 2016 a report entitled "*Informe sobre diplomacia científica, tecnológica y de innovación*". This report is issued by an Advisory Group created in November 2015 by the State Secretariat for Cooperation and for Ibero-America (SECIPI) and the State Secretariat for R&D&i (SEIDI). The report includes a series of recommendations to the Ministry of Foreign Affairs and Cooperation (MAEC) and SEIDI to shore up the central government's actions abroad in the areas of defence and of promoting Spain's interests more efficiently, taking advantage of the opportunities presented by Spain's strength in science, technology and innovation.

Germany has a longstanding engagement in Science Diplomacy that dates back to the end of World War II when its first science diplomats were sent to Israel. Today the German strategy for Science Diplomacy is spelled out in two strategic documents: the "Strengthening Germany's role in the global knowledge society: Strategy of the Federal Government for the Internationalisation of Science and Research", published by the German Federal Ministry of Education and Research (BMBF) in 2008 and the "Connecting Worlds of Knowledge" (Aussenwissenschaftspolitik) published in 2009 by the German Federal Foreign Office (AA).

Furthermore, it could be observed that some EU Member States are currently in the process of developing governmental strategies. This seems to be the case for Belgium, where on 1 December 2016, a conference on the topic "Science Diplomacy in Belgium" was organised by the federal Science Policy Office and the Flemish and Walloon/ Brussels regional administrations for Science Policy.

Outside the EU, some countries also offer strategic tools for science diplomacy. This is especially the case for the USA and Japan. But in general, one can conclude that the strategic thinking about Science Diplomacy as an instrument in the context of Foreign Affairs and international relations is not well articulated.

3.4.4. OPERATIONAL TOOLS FOR SCIENCE DIPLOMACY AT THE NATIONAL LEVEL

There exist many different operational tools across the different EU Member States that put Science Diplomacy in action. However, in most cases we are dealing with implicit forms of Science Diplomacy as the concept is not always mentioned. Furthermore, in line with the observed absence of strategic tools, the operational tools are not always clearly linked to Foreign Affairs policies. Below is an overview of the main categories of operational tools, illustrated with some examples.

3.4.4.1. BILATERAL OR MULTILATERAL S&T COOPERATION AGREEMENTS

There exists an incredible amount of especially bilateral agreements between countries that deal with one or another form of international S&T cooperation.

Given the sheer amount of S&T international cooperation agreements, it is no surprise that the drivers and motives of states to engage in international cooperation vary to a great extent. One can identified two broad sets of objectives for international S&T cooperation: (i) intrinsic objectives, directly aimed toward S&T substantiation such as cooperation among researchers or setting up large-scale infrastructures and (ii) external objectives focusing on the support of other policies such as foreign policies, economic/market policies or development policies.

All EU member states have concluded many such agreements, but only few of them refer to 'science diplomacy' explicitly as most of the bilateral agreements are related to intrinsic scientific drivers of striving for excellence and improving the national science system. This is probably related to the fact that in most cases, international agreements are dealt with by the ministries responsible for S&T as they normally have internationalisation in their portfolio. Germany and Italy are good examples that deviate from that position as the lead role is shared with the Ministry of Foreign Affairs. In 2012 for instance the Italian Ministry of Foreign Affairs and the Ministry for Research created together the *Innovitalia* platform.

In some cases, governments have set up dedicated agencies or intermediaries that play a pivotal role in the implementation of S&T cooperation. This is for instance the case in Germany with DAAD and in Denmark with the Funding Agency Coordination of International Tasks. In the UK, the British Council takes up this role, together with the research councils, the academies and the Science and Innovation Network (SIN), the DFID funds for international science and research for the purpose of international development.

3.4.4.2. S&T ADVISORY BOARDS

Not all EU Member States have S&T advisory boards or science advice structures that support governments. Good examples can be found in the Netherlands, Finland or the UK. The UK has had a long-standing tradition of employing a Chief Scientific Adviser, with direct access to the Prime Minister. Today this General Chief Scientific Adviser heads the 80-strong Government Office for Science while each ministry has a specific adviser. Interestingly, these practices are hardly ever labelled as science diplomacy.

A classic example of Science in Diplomacy, is the support of governmental foreign policy through input from the scientific community. This can be part of the mandate of a general advisory board for the government or it can be organised at the level of the Department of Foreign Affairs. In both cases however, this is mostly an implicit form of Science Diplomacy, as these practices are seldom labelled as Science Diplomacy.

Most European Member States have a scientific institute that is either directly attached to the Ministry of Foreign Affairs or that operates independently but in close connection to Foreign Affairs. This is for example the case in Belgium (The Egmont Institute for International Relations), the UK (Chatham House) or in the Netherlands (Clingendael).

3.4.4.3. S&T ADVISORS ATTACHED TO EMBASSIES OR FOREIGN AFFAIRS DEPARTMENTS

Only few countries in the world have created the position of Scientific Adviser in their respective Foreign Affairs ministries. This is for instance the case in the US, Japan, New Zealand, the UK and now also Senegal. In the US, the State Department has a Science and Technology Advisor to the Secretary of State. The Department of State Science Diplomacy strategy focuses upon overall participation from public and private sector organisations in areas that involve S&T. The American Association for the Advancement of Science (AAAS), in coordination with the State Department and other government agencies runs an ambitious fellowship programme[126] for training scientists in policy areas within the US Government.

A number of countries have S&T attachés or overseas liaison offices in third countries. This is the case amongst others in Austria, Denmark, Germany, Italy, the Netherlands, Sweden and the UK. Italy for instance has a network of experts and attachés that operates in 20 countries. They are people from Italian research bodies and universities and their role is to showcase

[126]) *https://www.aaas.org/program/science-technology-policy-fellowships*

and capitalise on the sectors of excellence in S&T and support the advancement of Italian companies in advanced technology sectors. The information they gather is circulated electronically to the Italian S&T communities. As for the UK, the Science and Innovation network (SIN) is jointly run by the Foreign and Commonwealth Office and the Department for Business, Innovation and Skills. The network consists of around 90 staff members, based in British Embassies across 28 countries and 47 cities worldwide.

3.4.4.4. OPENING OF NATIONAL OR REGIONAL RESEARCH FUNDING SCHEMES

International research cooperation is often seen as a form of Science Diplomacy as scientists have indeed a long tradition of cross-border collaborations. It is however debatable to what extent these collaborations count as Science Diplomacy as in most cases the scientists involved will not define their practices as such. Nevertheless, some states have developed explicit policies towards supporting international S&T collaborations. Often the driving force behind such policies is the belief that the national S&T capacity will benefit from such internationalisation. Next to investing in funding collaboration schemes this can also lead to a policy of opening up national funding schemes for foreign scientists. In some cases, the international research collaboration is stimulated as a way to retain cross-border contacts in situations where the 'normal' diplomatic relations are difficult. And, some countries invest in international S&T collaboration because they believe that their national interest is best served by research that addresses global problems.

Germany invests a great deal of effort in international cooperation in the fields of education and science through its Ministry of Foreign Affairs. For instance, since 2009, Germany has been building "Science Houses" in other countries, devoted exclusively to disseminating German innovation and science. The German Ministry of Education and Science has, since 2008, had its own office for the internationalisation of science, and several clusters that receive expert advice on the issue. The Ministry of Education and Science invested €3.4 billion in international research projects between 2009 and 2013. Another of the Germany's most important science ambassadors is the German Academic Exchange Service (DAAD), which annually provides grants to 120,000 students and researchers worldwide.

In the UK, two initiatives deserve to be mentioned: the Newton Fund and the Global Challenges Research Fund. The Newton Fund, administered by the BIS (now the BEIS), encompasses grants, projects and assistance for knowledge transfer and for scientific collaboration in 15 developing countries. The implementation is done by the British Council, the research councils and scientific academies. The Global Challenges Research Fund focuses upon international collaboration for development cooperation.

3.4.4.5. SUPPORT TOOLS AT THE NATIONAL LEVEL

In general, there seems to be no evidence of many support initiatives for science diplomacy at the national level in EU Member States. This in contrast with the US where since 2008, the AAAS Centre for Science Diplomacy is guided by the overarching goal of using science to build bridges between countries and to promote scientific cooperation as an essential element of foreign policy. The main purpose of such support actions are community building relationship-building and capacity-building in both the S&T and diplomatic communities. This can be done by organising trainings, conferences and exchange programmes.

3.5 POLICY IMPLICATIONS

Kerstin Cuhls, Marga Gual Soler, Jorge Manuel Lopes Moreira da Silva, Ivo Slaus, Helen Wallace, John Wood

Our contemporary world is currently at the crossroads. On the one hand, we are living in a world full of opportunities. On the other hand, our world contains many unsolved problems described in the Sustainable Development Goals framework – meaning our world is not sustainable, yet. We are currently facing manifold changes in the access to knowledge, in resource access, in education, in the future of work and jobs – and even in science itself. There is a worldwide consensus that the world is faced with a number of global problems that cannot be tackled at the level of individual states. Those global problems are of such a nature that they involve scientific knowledge in order to understand and tackle them. In other words, science can play a role in dealing with global problems and thus be used for the benefit of the world community.

Although "people are the true wealth of nations" (UNDP, 2010), monetary capital is still in the forefront; too many political decisions are not focused on either human or natural capital. Wars and violence, as well as terrorism, unequal opportunities in and among countries, the race for resources, chaotic migration and others remain the problems of today need solutions and lead to more and more closing down of regions, nations – and the EU. But with its high level of scientific excellence, the EU should be able to mobilise its scientific potential as a main means of action within its foreign and security policies as well as for the solution of global problems.

Our plea is therefore: remain open to the world, fight for solutions and not in wars, and make much more strategic use of scientific and evidence-based knowledge instead of instant opinion-generation which is more and more driven by the short-term Zeitgeist, latest events and opinion-providers (post-truth). The essential needs of human beings are among the challenges and we have to work hard on every level to safeguard our achievements and to make further progress. Political power has to be targeted on solutions to global societal challenges. The search for solutions must draw on the innovative power of the EU that is its strong base in science, technology and innovation, particularly since knowledge – a key element of soft power – is becoming predominant as a source of power (Toffler, 1990). A coherent vision for a joint Science Diplomacy strategy must include stronger coordination between the European Commission and EEAS, and between the EU and the Member States

Reviewing the three domains of Science Diplomacy, we see the necessity of their broad enhancement in the future:

- First for **science in diplomacy** there is a need for establishing systematic connections between scientific research and international relations, including the role of science in global governance. Until now, Science in Diplomacy occurs when scientists provide input or advice to foreign policy and decision-making, including global governance. But more and more, they also exchange information directly (professional networks, social media and others). The levels at which this advice is exchanged are broadening – the same for the uptake of advice. The diversity and cultural range of European countries should be seen as an asset not a handicap in this context. European understanding of cultural diversity elsewhere in the world can be exploited more effectively and within a coherent EU Science Diplomacy strategy.

- The second domain is **science for diplomacy**: new routes at different levels by which non-governmental but informed citizens, notably scientists, interact with other citizens. Science for Diplomacy uses science as a tool to build and improve relations between nations, whether to address shared problems or to mitigate tensions. In the future, there are many more opportunities in international projects (e.g. in FP9) for supporting this kind of diplomacy derived from the societal challenges or SDGs as exchange platforms or individual exchange programmes. If scientists as the "new science diplomats" are trained well for their new role, they are the new ambassadors with impact on both mutual understanding between nations and the quality of science itself.

- The third domain is **diplomacy for science**, i.e. international scientific collaboration facilitated by diplomacy .Diplomacy for Science promotes international scientific collaboration, using until today the classic tools of diplomacy to support the scientific and technological community. But more is needed: A high ranking ambassador at EU level could pave the way for high ranking consultations to resolve misunderstandings or to develop opportunities for critical forums about specific technologies that are on the agenda (e.g. nuclear power or gene technology). New routes of interaction are already taken by scientists and other citizens.

Open Science demonstrates that modern research is more international than ever, research is more collective and thus benefits from openness. The role of social media in a polycentric world enables physical boundaries to be less important. People-to-people Science Diplomacy on different levels has to take place in such a polycentric world. On the other hand, social media can feed people with prejudices and populist arguments not backed by facts. Here, the role of science as a generator of evidence-based and trustworthy knowledge needs to make use of new ways of communication.

A clear strategy for EU Science Diplomacy must include a support structure and intra-EU communication and collaboration on all levels. The European framework programme Horizon2020 is already open to the world and allows many countries to participate in joint scientific endeavours. It thus connects people and offers particularly promising ground for scientific collaboration and diplomacy. Whether a "Global Research Area" can be achieved may not yet be certain[127], but the European Research Area of the EU already provides valuable building blocks with connections to strong research centres across the world. Being open in science implies being fully accountable, transparent, inter- and multi-disciplinary. It also implies not only involving professional scientists but also engaged citizens to join scientific research (so-called "Citizen Science").

Training the EU science diplomats of the future

The new roles of scientists also require individuals who are specifically educated and trained in working together with policymakers, at all levels of science. This includes policy, communication, cross-cultural and language training, so as to contribute to diplomacy. The future rests on young people, who are digital natives, internationally linked in social media – and then educated as scientists. Science and technology diplomacy can contribute to: enhancing regional security in the European neighbourhood, improving European competitiveness and trade in the world, and tackling global problems, in particular by aligning the EU's Horizon 2020 programme with the UN's sustainable development agenda.

There are outstanding higher education institutions for science diplomacy in EU Member States and a remarkable AAAS Centre for Science Diplomacy in Washington DC that can serve as models for capacity building in science diplomacy in the EU. Including mechanisms for pairing and exchanging scientists and diplomats in embedded experiences is key to promote mutual learning and shared understanding.

Major progress is witnessed in all scientific disciplines and on all levels of scientific work – also in combination with communication and media use. Scientists nowadays rarely work alone – they are connected globally and include non-scientists. Working globally and addressing societal challenges demands continuous education, with learning and training components at a more advanced level than current higher education. Scientists of all disciplines need to be able to communicate effectively online and in-person. This demand for training in soft skills implies different job patterns and the involvement of a wider range of actors in the educational system.

Over half of the world's population is now within range of education and scientific material, with devices in their pockets that keep them in touch and able to call for assistance when available. Online courses open up higher education to a much larger portion of the society, significantly expanding human capital and developing the potential for more democratic engagement. All these capabilities have to be exploited much more actively. There is still a long way to go with providing training in project work, cultural understanding (speak the "same language" does not only mean that everybody speaks perfect English) and conflict resolution techniques on all levels.

Data and foresight for achieving the Sustainable Development Goals

In addition it is essential to collect data on a global scale. Data are close to becoming a new currency and the amount of data produced doubles every year. There are many opportunities, but some issues need to be addressed on the global scale – but with a European perspective: the large costs of data collection, the complexities of processing and interpreting large

[127]) Discussions at the Conference 'European Research Are@. Link. Shape. Develop', Workshop 7, Berlin, 10 October 2016.

quantities of data, ensuring the reliability of data, with attention to the privacy, human rights, and trust dimensions. Much more needs to be done to develop international collaboration on this.

To be prepared for future developments (positive or negative ones), there is a need to explore and debate alternative scenarios. The ability of science to anticipate risks and handle uncertainties and instabilities is much more systematic than politics. Hence foresight procedures including scientists should be reinforced to assess the desired directions in all fields of science, based on societal needs and addressing the both smaller and grand challenges. Impact and risk assessments can add information and guidance. Overall it is important to develop longer term views and assessments that go beyond the time horizons of the electoral cycles so as to promote more strategic actions.

The Sustainable Development Goals are based on this long-term approach and frame the quest for solutions. In addressing the problems, collaboration and diplomacy on all levels (explicit and implicit diplomacy) are necessary. The role of scientific advice and partnerships in addressing global challenges requiring scientific and diplomatic coordination, such as climate change, and the governance of international spaces, e.g. outer space, deep-sea, the Arctic and Antarctica are still underestimated. These issues cannot be managed through conventional models of governance and diplomacy, and will require flexible international cooperation and new tools of Science Diplomacy. Collaboration means working through pluri-national teams. Of course there is increasing pressure on budgets for innovation. A strong case has to be made for reinforcing our innovation capacities to address the challenges. These may lead us to game changers, e.g. the access to high performance computing capabilities and cloud technologies, decision-making algorithms and artificial intelligence diffusing into all societal challenges domains, or carbon capture and utilization.

All of these are relevant to global requirements. Science, technology and innovation are essential specifically for achieving the commitments towards the Sustainable Development Goals and the Paris Agreement on Climate Change[128]. Both documents are first steps towards a change in mindsets, promoting a new socio-economic and political paradigm on a worldwide scale. The essence of the Agenda 2030 is to leave no one behind, and to bring adversaries together. But there is still a long way to go with communicating, mutual learning and understanding, and conflict-solving techniques on all levels, all of which require a lot of diplomacy and coordination.

The same is true for the six Societal Challenges[129] currently under consideration in the European Commission. A core task is to ensure appropriate education for the people needed for creative work in sciences, in policy- and decision-making as well as to promote the EU's global priorities (Juncker, 2014). Their success depends on a longer time horizon, diplomatic endurance and perseverance.

It would be appropriate to start with experiments: experiments in specific target regions and then to broaden the engagement based on evolving experience. There are particularly strong grounds for closer collaboration with countries in our neighbourhood in Africa and the Middle East. There is scope to contribute to the reinforcement of research capacity and quality and of constructive relationships, including working on site with scientific and innovation centres addressing local problems.

[128]) Paris Agreement on Climate Change negotiated by representatives of 195 countries, opened for signature on 22 April 2016, signed by 177 and ratified by 15. Agreement will enter into force when 55 countries representing at least 55% of GDG emissions have formally joined it. The process is expected to be completed by 2020.

[129]) See Horizon 2020, 1. Health, demographic change and wellbeing; 2. Food security, sustainable agriculture, marine and maritime research and the bio-economy; 3. Secure, clean and efficient energy; 4. Smart, green and integrated transport; 5. Climate action, resource efficiency and raw materials; and 6.Inclusive, innovative and secure societies. See also Europe in a changing world, H2020, WP 2016-17, European Commission Decision C (2015) 6776 of 13 October 2015 or Kuhlmann, S./ Rip, A.: The challenge of addressing Grand Challenges. A think piece on how innovation can be driven towards the 'Grand Challenges' as defined under the prospective European Union Framework Programme Horizon 2020, Twente 2014. See http://ec.europa.eu/research/innovation-union/pdf/expert-groups/The_challenge_of_addressing_Grand_Challenges.pdf

Chapter 4:

Open Innovation

the need for a new policy narrative

TABLE OF CONTENTS

4.1. Introduction 125

4.2. Open innovation: An emerging and increasingly important topic 126
- 4.2.1. Definition of Open Innovation 127
- 4.2.2. Challenges to Policy-making in a Dynamic Open Innovation Environment 128
- 4.2.3. Opportunities for further research 129

4.3 The European Innovation Council: strategic reflections 130
- 4.3.1. Introduction 130
- 4.3.2. Open innovation in a closed Europe 131
- 4.3.3. A new EU perspective 132
- 4.3.4. The European Innovation Council: some basic principles 133
- 4.3.4 Case studies 139

4.4 Pro-Innovation Regulation 145
- 4.4.1. Introduction 145
- 4.4.2. On regulation and innovation 146
- 4.4.3. General principles for applying regulations 150
- 4.4.4. Recommendations 152
- 4.4.5. Conclusions 153

CHAPTER 4
OPEN INNOVATION: THE NEED FOR A NEW POLICY NARRATIVE

4.1. INTRODUCTION[130]

Francisco Veloso

The Open Innovation Working Group of RISE concentrated its reflections on issues associated with Open Innovation (OI) in the broadest sense. The Group consisted of members from academia and industry who worked closely with policy experts within the EC.

As in previous Chapters, the present Chapter presents first an overview of the concept of Open innovation as it has gained both academic and policy interest over the last 15 years. Given the current popularity of the concept in business and policy circles, it will be useful to clarify the concept, the way it has been interpreted in the academic business community and the way it has evolved into what can be called Open Innovation 2.0.

The second section presents the RISE experts strategic reflection on the idea of a possible European Innovation Council. Clearly, a key challenge for Europe today is how to align innovation policy with the characteristics of the current open and dynamic innovation environment, where "scale-up or fail fast" is an ever more important principle. This environment needs different policy tools than those designed in the past. It is critical to establish complementarities and synergies, adaptations and adjustments motivating and pulling in new stakeholders across a number of existing institutions, policy instruments and constituencies. The mission of an EIC has to address these challenges, while providing at the same time an impulse for innovative renewal at all levels of society. In practice, the vision put forward in this chapter is for an EIC that would focus on a few strategic elements, notably building synergies between different EU level instruments for innovation to maximize their added value on the European level, promoting the focus on people, openness and iterative results, and moving towards a new narrative around innovation and innovators.

To illustrate the latter, each one of us tells a story of successful innovators that illustrate some of the principles described above. Our cases are on Blabla Car, Feedzai, Abris-Capital, Adamed and Eataly. As a quick summary, BlaBlaCar is now the world's largest long-distance ridesharing community, with more than 25 million members across 22 countries and is one of the European unicorns at the vanguard of the sharing economy. Feedzai from Portugal is developing machine learning technology to detect anomalies in payment processing. Abris-Capital is one of the leading, independent private equity funds in Central and Eastern Europe. Adamed Group, originally from Poland, is a rapidly growing biotech/pharma company now active in over 60 countries. And finally, Eataly is a revolutionary Italian-own and globally operated market/mall chain that has redefined how food is experienced.

The third section of this OI Chapter is concerned with innovation-friendly regulation and regulation of the future. New types of innovation challenge the way regulation-business model innovation is conceived, the collaborative economy, design innovation, etc. Previously, structured governments interacted with structured companies; now, a decentralized system involving governments, firms and citizens with a high amount of mobility across jurisdictions is emerging and complicating regulatory interactions. This section presents a variety of reflections on "pro-innovation" regulation: what it means, why the European Commission might need to further develop and promote this concept, and some general principles for how to approach it. It assesses the requirements for applying regulations, highlighting the importance of an innovation principle which requires that whenever the EU's institutions consider policy or regulatory proposals, the impact on innovation should be fully assessed and addressed. Cases are provided from the sharing economy, from the energy sector, the so-called circular economy and summarize lessons from regulatory experiments in

130) This RISE chapter has been prepared by the Open Innovation RISE group on the basis of discussions amongst its members: Delphine Manceau, Anders Hvid, Stephan Morais, Daria Tataj Christopher Tucci, Francisco Veloso (chair) and Roberto Verganti.

the US. In the longer term, there is a need for a more horizontal, systemic view of innovation, rather than sector-specific thinking. In the short to medium term policy makers may also need to think about how best to work to make the existing regulatory and policy structures as innovation-friendly as possible.

The reader will surely notice that in this final Chapter, our reflections turn out to become more qualitative than quantitative, more forward looking than driven from an analysis of the past, more sensitive to inspiring cases and weak signals than by large numbers and average behaviors. This is due to the fracture in the nature of the dynamics of innovation. Unfortunately, in a moment of dramatic changes, the past holds limited information about the future. A mere examination and extrapolation of data from the past may lock us into a path dependent process of improvement. It is better to change trajectory, break through the past, and put forward novel directions that still have to happen.

With the auspices that new data will become available to better capture the new dynamics of innovation (concerning for example the new types of innovation such as business model innovation, design-driven innovation, user-driven innovation), and that better evidence will capture the new behaviors of innovation stakeholders (for example the interplay between start-ups and corporate innovation), the aim is to test the new lenses: the fundamental changes in how innovation and innovation policies may be seen.

4.2. OPEN INNOVATION: AN EMERGING AND INCREASINGLY IMPORTANT TOPIC

Christopher Tucci

There has been considerable academic, corporate, and policy interest in the topic of Open Innovation (OI) since the publication of the book by the same name by Henry Chesbrough in 2003, with over 13,000 citations to the work on Google Scholar as a broad measure of impact in academia and beyond. There have also been several special issues on the topic of open innovation in the last several years, including the influential academic journals *Industrial & Corporate Change, R&D Management, Research Policy, Research•Technology Management,* and *Technovation*.

In parallel with the academic impact of the topic, practitioner interest has exploded in the last ten years. Searching for the term on the Internet yields over three million hits. In addition, there are entire companies devoted to the OI process, practices within consulting companies specializing in it, and even corporate units within large enterprises to implement OI. Titles such as Manager, Director, or Vice President of Open Innovation are appearing with increasing frequency in such firms. With all of this activity has come many experiments in corporate innovation, leading to restructuring of research and development (R&D) processes of many firms worldwide.

The OI movement has also caught the attention of the policy world as governments around the word have sought to stimulate knowledge exchange and commercialization in their jurisdictions. For example, the European Commission (2016) published the book *Open Innovation, Open Science, Open to the World: A Vision for Europe* to explore those topics and their interrelations.

4.2.1. DEFINITION OF OPEN INNOVATION

One of the best and most concise definitions of OI was proposed by Chesbrough (2006): "*the use of purposive inflows and outflows of knowledge to accelerate internal innovation, and expand the markets for external use of innovation, respectively*." This definition is based on fundamental assumptions developed in the economics and management literatures on "knowledge spillovers," or whether and how knowledge "leaks" out of organizations that invest in knowledge development such as research and development (R&D). In many cases, the organization cannot entirely control the knowledge generated internally, and some of that knowledge can lead to serendipitous discovery within the organization. However, some of the knowledge developed can also "flow" outside the firm and many earlier studies in economics examined some of the pitfalls (free-riding from the organization's investments) and benefits (overall knowledge diffusion and possible related economic benefits) of such movements.

Research in management also emphasized that a focal firm could benefit from knowledge spillovers by scouting, building absorptive capacity, and even by forming joint ventures with the one making the specific investment. However, for the most part, from the point of view of the organization making the investment, knowledge spillovers were considered to be a negative thing because other firms were benefitting and the organization did not have complete control over its own outputs from R&D investment. The key insight from the newer literature on OI was that, while a focal organization may not be able to completely control the outflows and inflows of knowledge, it could manage these knowledge flows in a more systematic way, hence the term "purposively managed." First, in a continuation of prior work on absorptive capacity and learning from alliance partners, firms can develop knowledge transfer processes to bring external knowledge inside the organization. Second, firms can also develop processes to "export" knowledge and technology, especially those that might be considered less useful or less relevant to the core business. Thus organizations can design routines and mechanisms for both the inflows and the outflows of knowledge, making what was in the past considered mostly random or unpredictable into something that can be specified and controlled.

There has been much follow-on research in the ensuing years, tackling different contexts and nuances in the concept (e.g., Gassmann and Enkel, 2004; Dahlander and Gann, 2010; West and Bogers, 2014). Thus a more complete definition based on ten years of research in the area was proposed by Chesbrough and Bogers (2014): *Open innovation as a distributed innovation process based on purposively managed knowledge flows across organizational boundaries, using pecuniary and non-pecuniary mechanisms in line with the organization's business model*. As mentioned above, the knowledge flows can be "imported" into the focal firm via internal processes applied to external knowledge, "exported" from the focal firm via external commercialization processes, or even "coupled" (both at the same time, see Figure 1).

Figure OI.1: Import (outside-in), exporting (inside-out), and coupled processes

Source: European Commission (2016: 12).

Piller and West (2014) explore this coupling and how it might relate to the concept of "user innovation" wherein individuals develop products and services that they themselves need and which are then commercialized by other parties. The European Commission (2016) develops this idea (which they dub Open Innovation 2.0) further, discussing the central role that users play in both value creation (as in distributed innovation or crowdsourcing, e.g., Afuah & Tucci, 2012) and as the target of innovation in and of itself ("user-centric"). Open Innovation 2.0 also includes a well-functioning "ecosystem" or business ecosystem, where stakeholders or members of the ecosystem collaborate "along and across industry and sector-specific value chains to co-create solutions to socio-economic and business challenges" (European Commission, 2016: 13, see Figure 2).

4.2.2. CHALLENGES TO POLICY-MAKING IN A DYNAMIC OPEN INNOVATION ENVIRONMENT

The emergence of a much more open innovation environment and the speed at which radical and disruptive changes are taking place requires a significant rethinking of innovation policy. Innovation nowadays follows dynamics that are significantly different, sometimes even in contrast, with what happened only fifteen years ago. Several phenomena, most notably the digitalization of our society, the acceleration of events, the complexity of the context, mine the traditional way of looking at policy making. In particular, the following transitions characterize the new nature of innovation:

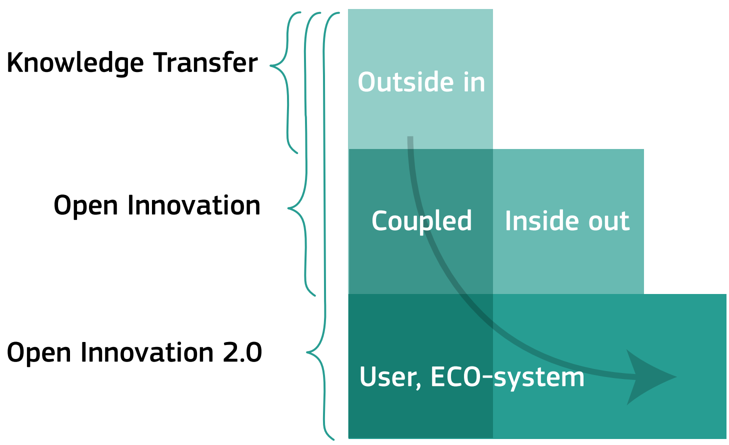
- Drivers: technology is nowadays only one of the many drivers of innovation. Significant value and growth comes also from other drivers inside and outside the focal organization, including business model innovation, design-driven innovation or user-driven innovation. Of course, technology is still relevant, but it is widespread globally and increasingly accessible, whereas entrepreneurial vision, empathy with customers and leadership are key to capture the potential of complex technologies.

- Processes: innovation nowadays happen at unprecedented speed, which makes planning attempts often useless; a base plan coupled with the capability to adapt and adjust is more valuable than depth and detail in analysis.

- Bottom-up: the difficulty of planning for innovation, coupled with a granularity of investments (especially when it comes to digital innovation), which enables experimentation with few resources, is turning innovation upside-down: most often breakthroughs are envisioned by pockets of creative individuals (often unaligned within their organization) rather than by top executives, especially in an open society, where access to external cooperation is increasingly viable.

- Iterative: innovation, especially non-technological innovation, does not always descend sequentially from science. It occurs through circular processes in which creativity, testing, and scientific analysis have mutual interplays.

Figure 01.2: Building on purposively managed knowledge transfer processes in an ecosystem



Source: European Commission (2016: 13).

These changes in the nature of innovation imply fundamental changes in the principles that underpin policy making, leading up to a set of reflections on the establishment of a European Innovation Council (EIC), as well as on the deployment of an innovation friendly regulatory environment.

4.2.3. OPPORTUNITIES FOR FURTHER RESEARCH

While the subsequent chapters explore and propose a variety of policy approaches to respond to today's environment of Open Innovation 2.0, there are many important research questions still unanswered and that will yield important contributions to this reflection. Tucci et al. (2016) identifies four questions for future research in OI: (1) Which boundary conditions underlie OI, or "when is more not better?" (2) How can "not invented here" be transformed into "proudly developed elsewhere?" (3) What is the best way to motivate and organize crowds of users? And (4) How can network forms of OI collaboration, such as communities, ecosystems, and platforms be better understood and organized? The third and fourth challenges are probably the most relevant to this chapter and the chapters that follow, which is briefly discussed below.

Bill Joy contributed greatly to the OI movement with the quote: "No matter who you are, most of the smartest people work for someone else." In the past, crowds were mostly limited to physical places but with the popularization of the Internet and software for massive collaborations now commonplace, there is a great need to understand the link between OI and crowd exploitation. What is now usually referred to "crowdsourcing" (although it goes well beyond being a simple source of knowledge) is now an important phenomenon in innovation, marketing, and even fundraising (via crowdsourcing) with an increasing amount of research in this area over the last 10 years (Villarroel et al., 2013). If crowdsourcing is considered as purely a source of ideas or problem solutions, this clearly relates to the "importing" of external ideas from outside the firm as developed above (Afuah, 2015). However, there is also an aspect of "expand[ing] the markets for external use of innovation" (Chesbrough, 2006) as well. In fact, crowdsourcing could also be considered coupling via the structuring and dissemination of the challenge (exporting) combined with the internalization of solutions proposed by users (importing). How broad and deeply does the focal firm need to search for solutions (Laursen and Salter, 2006), and can users (crowd) tap into their local knowledge to make it less "distant" from the knowledge of the focal firm (Afuah & Tucci, 2012)? What is the best way to motivate, reward, and organize large numbers of those smart users out there? Can they be organized or self-organize into communities, and if so, can that help with corporate innovation (cf., West and Sims, 2016)? Can crowd-sourcing be used for exporting and commercializing knowledge, and if so, how? And finally, thinking of coupling and exporting knowledge, how does that influence the focal firm's ability to capture value from innovation?

Moving on to the ecosystem and how it fits with OI research, OI collaboration in networks and ecosystems, communities, and platforms (Vanhaverbeke et al., 2014) also holds much potential. Network forms that help boost firms' innovation strategies via new innovation, development of complementary assets, and user-centric value creation are an important part of firm experimentation lately (Viscusi and Tucci, 2016). However, there has been an emphasis on specific ways of organizing in a network or ecosystem without thinking through higher-level topics such as the organization and exploitation of external OI collaborations (West and Sims, 2016). In addition, prior work has tended to concentrate on variation within specific forms of network organization rather than across forms, so our understanding of stakeholders interacting within different types business ecosystems has been limited. Research in this area would provide a real push to a better understanding of Open Innovation 2.0.

Finally, a relevant reflection concerns the role of open innovation for the new forms of innovation: business model, design-driven, experience-based, blue ocean, disruptive. These kinds of innovations are based on new "concepts" rather than merely "new technologies". The technology supporting AirBnB is relatively simple. The concept of peer to peer short renting was instead radical (to the point that earlier investors did not recognize the value of the concept). Studies on Open Innovation often implicitly focus on technology based innovation. Hence their attention to the flows of knowledge and ideas. But business model innovation and design-driven innovation, have totally different dynamics. The main asset is not knowledge, but entrepreneurial interpretation and vision. This kind of innovation challenges classic frameworks of open innovation; for example, when it comes to absorptive capacity, i.e. the capability to incorporate external knowledge. The challenge of business model innovation and design driven innovation is not how to incorporate external knowledge (which can be usually easily done), but it's at a higher level: how can we recognize the value of an innovation that redefines the parameters of value in an industry? The challenge in other words is not knowledge driven, but perceptive. It's not about solving, but about framing. It's not a matter of R&D, but of leadership, entrepreneurship and cultural change. Most innovation nowadays is widely available, but the problem of organizations is that they simply cannot recognize their value because they play on new performance parameters. Especially when, as in design-driven innovations, these parameters are symbolic and emotional. On top of this, concepts are difficult to articulate, protect, license. Their circulation is easy. Their interpretation is hard.

Hence the need to investigate how open innovation occurs when what is at stake is not knowledge, but concepts.

4.3 THE EUROPEAN INNOVATION COUNCIL: STRATEGIC REFLECTIONS[131]

Daria Tataj and Roberto Verganti

4.3.1. INTRODUCTION

This second section reflects and discusses the establishment of a possible European Innovation Council (EIC) with as central aim the strengthening of European innovation policy while at the same time promoting a more open culture of innovation and entrepreneurship across Europe. The idea is to consider the EIC as an instrument to bring innovation policy in Europe in line with the characteristics of today's open and collaborative innovation as discussed before, providing at the same time an impulse to innovative renewal at all levels of society.

The success of the EIC would manifest itself in the long-term by evidence that its initiatives have created an innovation-friendly environment and new policy instruments, which significantly facilitated the growth of high-potential 'scale-up' firms by helping them access large markets, talent, funding and strategic decision makers.

The core innovation principle of today "scale-up or fail fast" needs different policy tools than those designed in the past. The creation of complementarities and synergies, adaptations and adjustments motivating and pulling in new stakeholders across a number of existing institutions, policy instruments, constituencies would be central to the EIC.

The EIC would focus on a few strategic elements, notably building synergies between different EU level instruments for innovation to maximize their added value on the European level, promoting the focus on people, openness and iterative results, and moving towards a new narrative around innovation and innovators.

[131]) This section has been prepared on the basis of inputs from RISE experts from the Open Innovation Delphine Manceau, Anders Hvid, Stephan Morais, Christopher Tucci, Francisco Veloso and Open Knowledge Markets working groups in particular João Caraça, Luke Georghiou, Frederique Sachwald, Luc Soete, coordinated by Daria Tataj and Roberto Verganti.

4.3.2. OPEN INNOVATION IN A CLOSED EUROPE

As highlighted in the previous section, over the last year, innovation has not just changed conceptually; it has also changed in its concrete applications. Open or collaborative innovation[132], user-driven innovation[133], design-driven innovation[134], frugal innovation[135], workplace and remote working innovation have become the norm with a crowd-sourcing[136] of ideas and crowd-funding of new, often highly motivated stakeholders (see the cases on Eataly included in appendix as an example of how new innovation models arise and grow). Innovation has taken the form of new business models[137] often anchored in 'shared economy' (see the case on BlaBlaCar in the Appendix) and emerged under new forms of social entrepreneurship, intrapreneurship, digital nomads, impact investment as well as industry-led sustainability and social responsibility programs. While competing on novel technologies such as artificial intelligence, machine learning, biotech or brain science can provide Europe a technological edge, the shift towards service economy and value-added manufacturing are critical for growth and jobs in Europe.

At the policy level area, it could be argued that the European Union has a relatively sound track record. The establishment of the European Research Area and European Higher Education Area, Framework Programs, new institutions such as the European Research Council, the European Institute of Innovation and Technology and its Knowledge and Innovation Communities, Joint Technology Initiatives, are now all part of the European innovation system. Recently, there have also been efforts to strengthen the entre-preneurial drive across Europe, with the Small Business Act, Start-up Manifesto and Europe's winners of tomorrow: The Startup and Scaleup initiative[138] being key examples of these attempts.

However, viewed from a global perspective, Europe has lagged on the scaling up of innovation into global economic value[139]. In addition, the global war for talent has often drained Europe of some of its most creative and entrepreneurial innovators[140]. The traditional policy instruments, which already struggled in the past, do not really match the new innovation context. In the era of digital society, experience driven competitiveness of products and services, and the emergence of industry 4.0 the world changes ever more rapidly. And so should innovation policy and its instruments.

At the dawn of the mid-term Horizon 2020 review, this is the time to rethink what it would take to get more out of Europe's investment in research and innovation, to boost economic growth, create new and better jobs, stimulate future European leading companies in all the key industries of the future, and advance our ability to mitigate key challenges and anticipate mega-trends of our times. The challenges are many: demographic changes and migration, climate change and mortal diseases, security – including cyber security, food and social unrest. But with challenges always come opportunities.

A possible European Innovation Council ('the EIC') would be an opportunity to renew innovation policy while strengthening a new, open culture of innovation and entrepreneurship across Europe. Its success would ultimately manifest itself by evidence that its initiatives have significantly facilitated the growth of high-potential

[132]) *Henry Chesbrough (2003), Larry Huston and Navil Sakkab, (2006), Gary P. Pisano and Roberto Verganti (2008).*

[133]) *Eric Von Hippel (2005), Karel Vredenburg, Scott Isensee, and Carol Righi (2002). Robert W. Veryzer, and Brigitte Borja de Mozota (2005).*

[134]) *Roberto Verganti (2009), Donald A. Norman and Roberto Verganti (2014) and Tim Brown (2009).*

[135]) *Abhijit Banerjee and Esther Duflo (2012).*

[136]) *eff Howe (2009).*

[137]) *Alexander Osterwalder and Yves Pigneur (2014), W. Chan Kim and Reneé Mauborgne (2005). Alexander Osterwalder, Yves Pigneur, Greg Bernarda, Alan Smith, Trish Papadakos, (2015), Delphine Manceau and Pascal Morand, (2014).*

[138]) *COM(2016) 733 final*

[139]) *Giovanni Dosi, Patrick Llerena and Mauro Sylos Labini (2006)*

[140]) *See for instance Bruegel (2015).*

'scale-up' firms, by facilitating access to markets, talent, funding and strategic decision makers. Scale-ups are important drivers of innovation-led growth and employment creation[141]. It would also be relevant if it would promote different sources and types of breakthrough innovation, whether it is led by research, business models, design, organization, customer experience.

4.3.3. A NEW EU PERSPECTIVE

In this new business environment, policy makers necessarily need to change the set of policies and policy instruments which support innovation. And the global and collaborative nature of such changes creates a gap that should be filled at the EU rather than Member State level. This is particularly relevant for breakthrough innovation that scales up into large businesses, also referred to as "market-creating innovation". This specific kind of innovation is more likely to happen if addressed at the EU level.

First, breakthrough innovation needs a pool of specialized and talented resources as well as "early adopters" to help achieve market success. Market-creating innovation is inherently more risky, which implies acceptance of failures, hence larger budgets and deal flows. Local policies, that have smaller deal flow and budgets, can hardly afford the ratio of successes/failures that lead to breakthrough innovation. This innovation also cuts across different fields, and therefore it requires a broad horizontal scope of action. Local policies, that have limited resources, are effective when focusing their budget on specific fields or industries. A set of instruments at the EU level could complement local policies by supporting the most unpredictable innovation, the innovation that moves horizontally across the borders of existing industries, that comes unplanned from the bottom up, and from unexpected networks. This necessarily requires a span of action and a scale that moves beyond national borders.

Second, an instrument to intervene at the European level needs to focus on enabling innovation that creates substantial growth. The focus is accompanying talented innovators from idea exploration, to development, to scale-up into large businesses with a European and worldwide reach. This scaling up can be more successful if orchestrated at the EU level for many reasons. The first aspect is that it will benefit from the single market advantage, which is critical to scale-up rapidly. All too often high potential start-ups move to the US because they can access a larger market faster, while lacking a door that would allow them to follow the same path in the EU market. (see the case on Feedzai in section 4.3.4 as an illustration to this point). In particular, European start-ups have a short supply of growth capital which is a function of a chronic lack of appetite for risk from European institutional investors, is stark contrast to their US counterparts that deploy vast amounts of capital to the Silicon Valley based Venture Capitalists that are behind most global technology champions. EU based Venture Capital firms are therefore much smaller and fragile than their counterparts and hence most European success stories become American at some stage (see Abris-Capital[142] for an example of these challenges). An EU approach can also rapidly capitalize on best practices across Member States benefitting the integrated tools and solutions, but also helping disseminate such practices across the EU. An integrated perspective would also help championing innovation friendly regulation at EU level, an increasingly critical element in today's sharing and digital economies. Finally, an EU approach also seems to be the only way to strengthen and deepen growth capital, particularly funding beyond "the Valley of Death," an area where Europe is severely lacking.

The EIC as a European Union initiative should leverage its convening power to develop more 'switching capacity' between diverse, multilayered innovation networks. Thus, it would facilitate the emergence of a more open, collaborative, agile innovation eco-system across all Member States linking peripheries of innovation networks to major hubs and facilitating flows of knowledge, talent and funding.[143]

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141) A 'scale-up' firm is an enterprise with average annual growth in employees or turnover greater than 20 % per annum over a three-year period, and with more than ten employees at the beginning of the period. See the so-called UK Scale-up Report http://www.scaleupreport.org . «Sherry Coutu's 'Scale Up Report' zooms in on one of the most pressing growth challenges faced not only by the UK but many other advanced economies: how do you move beyond creating start-ups, and prepare the ground for companies to grow and create meaningful economic impact? This focus on the quality and not just the quantity of entrepreneurship helps the reader to gain new insights into what policy steps should be taken." (Michael Porter, 2015)

142) See section 4.3.4 for more details on the history of the emergence of each of those cases.

143) Daria Tataj in her book Innovation and Entrepreneurship. A New Growth Model for Europe beyond the Crisis (2015) offers a perspective how to build a replicable model of networked innovation ecosystems on national, regional and pan-European scale. The book is based on research conducted under the guidance of Professor Manuel Castells and experience in establishing the EIT and its first Knowledge and Innovation Communities.

Complementarities with other EU Actions

In pursuing its mission, the EIC would complement the actions of the ERC (European Research Council) and the EIT (European Institute of Technology) with its specific networks of businesses, universities, research institutes and non-profit organizations called KICs (Knowledge and Innovation Communities).

It would complement the ERC (that focuses on blue-sky research), by providing an empowered arena to transform research into successful innovation and relevant business extending in principle the value chain from the frontier of science to the frontier of innovation.

In doing this, it would complement the EIT and the KICs by providing a wider context of innovation-friendly environment and scale-up opportunities for ventures coming out of KICs. By creating a one-stop-shop for innovators of any nature, and in particular addressing innovation that: (1) is driven by any driver (i.e. not only technology, but also, for example, business model innovation, or design-driven, customer experience driven, or organization driven innovation); (2) happens openly beyond specific fields, i.e. that does not occur within the fields of the EIT, or happens at the intersection of those fields; (3) can be easily accessed by players who do not belong to established KICs yet but who can become their partners catalyzing the dynamics of the whole networks and extending their value chains across global markets.

These are important arguments to develop the support for breakthrough innovation at the EU level. Thus, an instrument to act at this level should integrate these opportunities and develop a value proposition that brings in single market advantage, access to a larger pool of talent, knowledge and capital, orchestrates different European and local initiatives.

4.3.4. THE EUROPEAN INNOVATION COUNCIL: SOME BASIC PRINCIPLES

Mission

The key mission for an EIC is to bring innovation policy in Europe in line with the characteristics of emerging modes of innovation, providing at the same time an impulse to innovative renewal at all levels of society. The innovation principle of today is "scale-up or fail fast". This would be reflected in the design of the EIC and manifested through its lean administration, digital presence, openness to experiment, trust-driven rather than control-driven culture, and bias towards disruptive innovations.

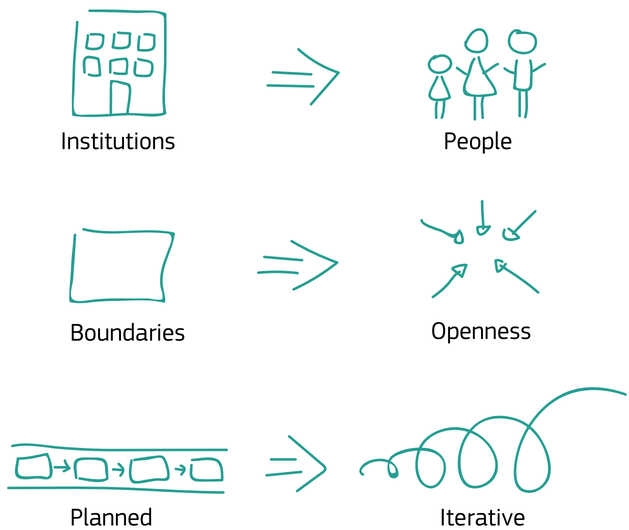
Given its purpose and mission, the EIC would in its initial phase focus on creating complementarities and synergies, adaptations and adjustments, motivating and pulling in new stakeholders across a number of existing institutions, policy instruments and constituencies, helping existing instruments and initiatives achieve a larger impact and maximize their added value on the European level.

To fulfil its mission, the EIC should empower the best innovators. Similarly to what happens to the ERC, that attracts the talented researchers, the EIC wants to attract and support talented innovators: both innovators with a successful track record, but who are not finding support to their latest development, and the top innovators "to be", i.e. those who have the best potential. It should foster openness and build its success on accountability and ambition of innovators supporting them adequately at different stages with a seamlessly integrated funding scheme following a value chain thinking. The focus on people, openness and iterative results, and moving towards a new narrative around innovation and innovators is thus at the core of this perspective for the EIC (see Figure 01.3)

Focus on people

The key players of innovation are people, not institutions. Ideas, knowledge, motivation, engagement comes from talented people working in team. The EIC should be the one-stop-innovation hub for people, wherever they work (in start-ups, small, or large organizations, research organizations). "Not everyone

Figure 01.3: New dynamics of innovation



Source: Authors

can become a great artist, but a great artist can come from anywhere," says restaurant critic Anton Ego in the movie Ratatouille. Thus suggests that individuals who harbour interesting hypotheses may lie in unexpected pockets of the socio-economic system. Only an open, internationally scoped organization can help them to emerge. In addition, an EU level organism, means that top innovators who are stuck into local existing networks, and can't find local support, have a chance to break outside of these existing networks by moving at an European level (both in terms of selection of their proposals, identification of the team of innovators, and choice of hosting organization). Indeed, the most successful programs that focused on people (Erasmus, Marie Curie, and now the ERC), have operated on an European level.

This means that promotion, funding, and other actions should be addressed to the talented people with an innovative idea, passionate to transform this idea into a successful business. The users would be responsible for the project, to be conducted within a Hosting Organization (any setting public or private, new or established would be possible; see below). She/he would not act alone of course, but in cooperation with a Team that she/he identifies and leads.

Breakthrough innovation requires ingenuity, energy and leadership. Leadership is a key factor since disruptive change requires a clear vision and a clear sense of commitment towards nurturing the innovative idea and catalyzing different resources. It is well known that successful venture capital fund managers judge the qualities of the entrepreneurs-to-be and their teams rather than only their idea and market potential. Thus, a focus on people and leadership might also facilitate assessment procedures, as it is often more important to evaluate the potential of people, than the potential of an idea.

The EIC wants to promote innovation at the pre-involvement stage of private funding. This innovation typically comes from people whose ideas struggle to be recognized by their normal organizational settings. As a result, such innovation would mature slowly, or not mature at all, in the absence of public support, because it is usually too early in the development stage, or too far from the strategic priorities of an existing organization, or perhaps too risky for private investors. By targeting individuals, the EIC therefore would support development of those breakthrough innovative ideas that transform organizations, beyond existing trajectories, and therefore become disruptive in the market. Yet, while targeting these breakthrough ideas which are inherently risky, the use of public funding still requires accountability. A people centric approach may also facilitate such accountability because there would a person, the innovator, responsible for the initiative.

Last but not least, focus on people would promote an innovation policy that is designed around Europeans as agents of change instead of European institutions. The EIC would be contributing to establish a community of the best innovators in Europe.

Focus on openness

To fulfil its mission, the EIC should promote open, collaborative and crowd-sourced modes of innovating. This means the EIC should not define a priori any type of area, industry or market in which to focus, but adjust its funding policies to emerging challenges led by citizens as consumers and by public needs. If this is the case, the innovator would decide on a project, and on the best team to support her/him in the innovation endeavour. This would mirror what happens in the ERC, where the Principal Investigator can employ researchers from any nationality as team members.

Such an approach would mean *no traditional boundary conditions typical to European funding schemes defining* number of countries involved, type of organizations (businesses, academic), size, amount of subcontracting, nationality of the team members. The assessment of a project would consider the quality of the team and the quality of support provided by a possible organization, as well as the level of potential market disruption and expected return on investment to make the project attractive for subsequent private funding.

The timing of proposal submission should be very flexible, with high frequency of deadlines, and quick decision making process, leveraging elements of assessments conducted under other European schemes.

Focus on iterative results

How to select promising but far-fetched ideas in a fast changing and uncertain world? The answer is simple: it is impossible. Definitely, the old approach of innovation policy measures, based on long complicated procedures (planning-calling-screening-controlling), does not work for promoting innovation today. Access to funding in the EIC should be based on simple, steadfast and iterative procedures.

First, it is important to avoid traditional planning and the notion of calls (see the principle of openness above). The EIC should be open to receive proposals at frequent deadlines in any field. Applying should be made easy and fast, because support is to be provided in small chunks, following a process of similar to that of the SME instrument. Thus, a project that already received support should be able to quickly apply for further funding. This keeps risk of failure to small amounts, screens off unpromising paths early along the 'fail fast' principle, and avoids the impossible long-term planning and unrealistic a priori long-term evaluation of projects.

Second, screening would naturally consider the potential of the project, but the qualities of the *person[s] and team* who propose them (past track record and assets) would be especially relevant on the initial stages of the project. Moreover, following an iterative approach, the results of earlier stages would be used to assess support decisions for follow-on stages. Depending on the nature of the project, the role of the host organization might also be considered in the assessment; its serious embracement of the project should in any case be part of the evaluation.

Third, the EIC should control results rather than focus only on input or throughput indicators. Innovation can hardly be recognized ex-ante, but can be more easily recognized ex-post. Every EIC project should be carefully controlled ex-post on results. Failure in achieving results would not necessarily be punished, as failure is very likely to happen in innovation, but any loss would be limited given that projects are small and iterative. However, failing to achieve results prevents access to subsequent stages of funding, and enters into the track record of the innovator and her/his team, thus diminishing their chance to get funding in the future.

Last, the EIC should develop a new incentive system for the evaluators. Venture capitals firms carefully select promising entrepreneurs because they have an incentive on seeing them succeed. The expert evaluators of EIC should operate in a similar way. Their compensation should be in some part dependent on the success of the project they screen. In addition to a base compensation for every proposal they screen, they could get an additional bonus when a project achieves innovative results and market value. Similarly, finding ways to involve private funds and investors at every stage of the decision and funding process would naturally align incentives and help evaluation processes.

The consequence of the principles above is that the policy tools of EIC would mirror the nature of current innovation. They would be fast, simple, open, and attractive to any European citizen with good ideas and a strong commitment to innovate.

Principles and implementation

To assure that such principles are appropriately considered, several elements are to be pondered when designing instruments. First, an EIC would need to bring about synergies amongst existing funding instruments for innovation and entrepreneurship support at EU level, consolidating and restructuring of the complex landscape of EU policy instruments. Moreover, it would important to build on the most open and bottom up instruments that exist today, such as SME Instrument, FET Open and Fast Track to Innovation and/or Eurostars. An EIC could pull those instruments closer together, improve their evaluation procedures and streamline their governance. A related element would be to assure the establishment of a (digital) platform to help navigate European funding for innovators and for innovative firms with 'scale-up' track record or high potential. Such platform would be an important basis for this integration and streamlining.

The second important element is the concern with the EU missing out on a flow of breakthrough innovative projects that scale-up to become major global players (see Adamed case for an example of these growth steps and challenges). Breakthrough innovations are simply getting lost along the various development stages. Such concern requires the EIC to have instruments that can support, increase and accelerate the creation of these breakthrough projects, and accompany them through the scaling-up process. EIC funding instruments should therefore cover the different phases of the innovation process into scaling-up, and to do that with an EU perspective.

When considering earlier stages, this often means tackling a lack of adequate funding on the market, especially "fast money," such as small grants for rapid prototyping. But it should also mean having a more encompassing perspective on the nature of projects, and the organizational setting of the promoters. In fact, it would be important to consider independent entrepreneurs who fail to explain their intuition to investors, researchers that don't quite understand how their technology can be ported into a product that a client will buy, but also people who work within firms struggling to show the value of their ideas to top executives. It is critical to be able to target ideas that grow within existing organizations but that remain unexplored because their value is not fully recognized within processes geared towards incremental change. Most entrepreneurial initiatives are born and start to grow within existing organizations, including universities, research and technology centres, as well as larger established firms. When they start to mature, they are launched as autonomous spin-off firms. Many very successful firms, including ASML (a semiconductor production systems company which emerged from Philips) and Circassia, (a biotech company from Imperial College) have emerged through such a process.

And if the goal is to induce or source new ideas, it would be relevant to consider tools such as "Idea competitions" across the EU, which could reward particularly innovative ideas sourced from anywhere, and might be specifically designed to address the societal challenges mentioned in the EU 2020 Strategy. Complementary, the use of crowd-funding markets can be stimulated, by engaging citizens in funding issues of global importance, such as societal challenges.

The EIC should thus provide any person with a great idea and great will the tools and support that allows her to explore her idea until to a level of maturity to be presented to investors. As noted above, the approach should leverage and improve existing successful policy instruments such as the SME instruments and the funding scheme of the ERC, with its focus on principal investigators and hosting organizations, ease of access, and flexibility.

The other critical element that ought to be at the core of any EIC tools and instruments to be developed is to increase the availability of growth capital. Yet, a critical question when considering any public funding for scale-ups, even if there is a demonstrable market failure, is how to assess project quality, while making sure that it does not crowd out private agents. A way to address these concerns is to consider co-investment schemes, whereby accredited European VCs with demonstrable track record are pre-qualified or called to lead investment rounds in promising scale-up firms, with public funds matching their investment. This would enhance greatly the fire-power of European VCs. In developing scaling-up instruments, the EIC might partner with the innovation arm of EFSI, exploiting fully the technical and financial expertise of EIB and EIF.

Finally, it is also important to consider the key role played by large corporations in the scale-up of breakthrough innovation. The EIC can have a positive contribution by bringing corporations and start-ups/spin-offs closer and therefore increasing the likelihood of scale ups emerging. The EIC can engage institutionally with hundreds of corporations throughout Europe and effectively promote the matchmaking with start-ups that want access to corporate partnerships.

From Innovation to Innovators. A New Narrative

The EIC could also have a mandate to promote European success stories worldwide, creating benchmarks and cases that can be used to spread the word, both as role models and measures of high achievements. The aim is to promote and sell European entrepreneurial innovation outcomes and impacts across the world.

A communication plan should be implemented so as to show how EIC funding has made a difference on some projects, and also how European talent can create radical innovation.

The objective is also to make Europe appear as key area in the innovation world map. The key principle here would be to tell the stories of people, i.e. the innovation team. The story of people, rather than merely the description of the innovative product, or quantitative output, is crucial to inspire others and to give depth to the communication (for an example of a narrative of a European success story see the case on Adamed).

The following tools could be used:

- Compile and communicate success stories of European innovators that are game changers in their industries and have a global reach.
- Gather those innovators in an annual events where journalists, experts, innovators could exchange practices and present their story.
- Organize idea challenges around these events, prize competitions for the most talented European innovators each year.

In time, these success stories will also enable to provide a general analysis of the impact of EIC. Now these success stories of European innovators are impressive yet dispersed as demonstrated by the case studies below. Bringing them into one place also virtual would reflect a fascinating way how Europeans change the world of hundreds of consumers and users for better.

In order to make EIC more visible, another part of the communication plan would go beyond successful innovators and gather data on the evolution of innovation and entrepreneurship within the EU. Since a key objective of EIC is to promote an entrepreneurial mindset within the EU, it could follow how mindsets evolve throughout Europe. The idea would be to not only monitor the direct impact of EIC funding, but the dynamics it creates or accelerates within Europe about innovation and entrepreneurship. Indicators such as number of start-ups created in Europe, amount of private capital invested in start-ups, number of European students creating their company just after graduation, number of European companies being leaders in key innovative industries, number of gazelles, shall be monitored at the EU level so as to see how things evolve within Europe. Another indicator to be followed would be the number of start-up head offices being delocated from Europe and relocated in Europe with relevant re-immigration policy.

Measuring impact

To measure impact the EIC should engage the public rather than only statistics and numbers. It should harness the collective intelligence of people at all levels of the innovation process including users, which could be potentially also involved in some of the EIC funding schemes to assess a relevance of an idea or solution. Crowd-sourcing approaches are aligned with the 3 O's policy of Commissioner Carlos Moedas.

The EIC and its initiatives should have goals and measures of success. While it is premature to propose exactly what those indicators should be, they could possibly include:

- Customer satisfaction surveys among applicants and beneficiaries of the EIC programs
- Attraction of talented innovators
- Progress and success factors of the EIC instruments and programs
- Attraction of external private and public funding
- Recognition by general public and by stakeholders

The EU Innovators – Exemplar stories

Daniel Ek, a 33-year-old Swedish entrepreneur, founded his first company at the age of 14. He then created and was a part of many companies: the Nordic auction company Tradera (later acquired by Ebay), Evertigo, Advertigo which he sold in 2006... Also in 2006, Ek was briefly the CEO of µTorrent, working with µTorrent founder Ludvig Strigeus. This ended when µTorrent was sold to BitTorrent in 2006. This same year, together with Martin Lorentzon, he set up the concept of Spotify, a music streaming service. Note that Strigeus who had founded µTorrent would join Ek as a Spotify developer. In 2008, the legal music streaming service Spotify AB was launched. Daniel Ek still serves as the CEO of Spotify. Initially, Spotify ran on a peer-to-peer distribution model, but switched to a server-client model in 2014. Spotify is now a music, podcast and video streaming service that provides digital rights management and protected content from record labels and media companies. It is available in 50 countries, in North and South America, Europe, the Middle East, Australia, South-East Asia. It now has more than 100 million active users, 30 million paying subscribers worldwide and about half a billion registered users.

Cristina Fonseca, the 29 year-old co-founder of the very successful cloud call-center company Talkdesk is a Portuguese female entrepreneur that built up her company from scratch over the last 5 years. Talkdesk currently employs hundreds of highly skilled employees in Lisbon and Silicon Valley and counts as clients companies such as Dropbox and Shopify. Having raised significant capital from 500 Startups, Salesforce Ventures, Storm Ventures and DFJ Venture Capital, Cristina was recently named a Forbes 30 under 30.

Jacques-Antoine Granjon, 54, created his first company with a friend when he was 23. Cofotex was specialized in the wholesale of overstocked goods. It then progressively moved into the concept of flash sales – sales that last only a few days or a few hours. In 2001, with 7 associates, Jacque-Antoine Granjon launched vente-privee.com, the first online flash sales platform. Originally specialized in fashion goods, the site progressively enlarged product categories to be sold, including travels, music and food. It now operates with 6000 brands and generated a turnover of 2 billion € in 2015 in 13 countries (including Spain, Germany, Italy, UK, Austria, Netherlands, Denmark...), with 5 million users and a staff of 4000 people. In 2011, Jacques-Antoine Granjon launched with several partners l'École européenne des métiers de l'Internet. He also invested in several projects and companies, as well as in a theatre and a music festival. He strongly supports the Paris start-up scene.

Olga Malinkiewicz, 34, is a Polish scientist turned entrepreneur. She pushed the boundaries of science by developing a novel technology for the production of low-temperature technology of ultra-thin and flexible perovskite-based photovoltaic cells. Instead of pursuing a career at the University of Valencia, where she filed for the patent, she returned to Poland to start a company. In 2014 Saule Technologies was founded and became one of the first companies in the world to succeed in developing a working prototype for the commercial use of perovskites. The road to the success was bumpy with access to funding as the major issue. In 2015 the company got over 6 million EUR grant from the funds of the National Centre for Research and Development, leading agency managing European Union and National funds for research and innovation in Poland. The same year, Saule Technologies signed the investment agreement with Hideo Sawada, a Japanese businessman. Olga has been greatly recognized internationally. Published in Nature, featured by Forbes Poland, she received the prestigious Photonics21 award in a competition organised by the European Commission and the title Innovator under 35 by the MIT Technology Review. Her entrepreneurial success would have never been possible if not for her ambition as well as her business partners, Piotr Krych and Artur Kupczunas, two experienced businessmen who have helped Saule Technologies grow globally.

While there would be a number of quantitative indicators to monitor and assess the impact of the EIC, there would surely be other impacts that are harder to capture with numbers. They should range from strengthening the process towards better European legislation for innovation; empowering successful commercially-minded innovators some of whom may choose to stay in/return to Europe; engaging European citizens in decision making and funding innovations; and building the brand of European innovation around the globe.

While the ideas for the EIC drafted in this section require further thought, they are presented as a reference point to stir discussions among innovation actors, entrepreneurs, investors and policy makers. But the key question to be answered is the 'how' question: how to stand up to the ambition, how to ensure fast execution, how to make the innovation system more agile and flexible, how to integrate funding schemes from start-ups to scale-ups and how to mobilize private funding? These are by no means trivial challenges. The speed of change will surely depend on empowering entrepreneurial talent to drive transformation of innovation and entrepreneurship policies in Europe and implement them across the Member States.

4.3.4 CASE STUDIES

It would be important for the EIC to promote European success stories that could be considered one way or the other as typical examples: "role models" of what an EIC could over time achieve. Based on individual national expertise, this section presents a list of such success stories coming from different Member States, different sectors, some well-known others far less. This collection briefly presents the stories of BlaBlaCars, Feedzai, Abris-Capital, the Adamed Group, the Green Group and Eataly. The cases illustrate that in different formats, under different historical conditions, covering very different regions in Europe, such success stories do exist.

BlaBlaCar: New innovation models

Delphine Manceau

BlablaCar is a pertinent example of innovation as it occurs today. Its carpooling concept is innovative in terms of user behavior and experience as well as business model. It is not a technology push innovation, even though digitalization is a key component enabling supply and demand to communicate and match. In line with sustainability issues and the better use of goods, it creates new markets and does not fit in any existing industries, neither public transportation nor the car industry. Incumbent companies such as the car manufacturers or car insurance companies wonder how they should integrate this new approach in their own development models.

BlaBlaCar was founded by Frederic Mazzella, a French entrepreneur. He discovered ride sharing during his student days in the US where, every morning, he shared a car with three friends to go to university. At the time, there were public incentives for carpooling on California highways.

But the idea behind BlaBlaCar came up in 2003, when, travelling home for Christmas, he observed many empty car seats available but no way to access them. He realized that there was no website providing a list of seats available in cars for long distance journeys. His vision was then to create a ride sharing service that would enable carpooling throughout France between people who do not know each other. The idea was to operate as an online marketplace and to pair motorists with passengers needing a lift between cities.

During the process, Frederic Mazzella partnered with Nicolas Brusso and Francis Nappez and those three cofounded the company.

In 2008, the concept was launched as the "2.0 web community covoiturage.fr", conceived as a mix between a travel agency and a networking tool in which "Booking meets Facebook." It was originally both C2C (free) and B2B, selling the software platform to companies to encourage ridesharing amongst their employees. 200 platforms were sold on the B2B market, but without generating profits due to costly customization. It was then decided to focus on the C2C market by connecting drivers and passengers willing to travel together between cities and to share the cost of the journey. BlaBlaCar takes a 12 % commission on each journey and is geared toward motorists looking to fill empty seats during long distance journeys they would have been making anyway.

BlaBlaCar scaled up quickly and grew international by being introduced in Spain in 2009, and then in the UK in 2011, a market that finally appeared to be disappointing in terms of volume. It was introduced in the Netherlands, Luxembourg, Belgium, Poland, Italy, and Portugal in 2012, Germany in 2013, Turkey, Ukraine and Russia in 2014. In Italy, Ukraine and Russia, the company also bought local carpooling actors so as to assess its position.

BlaBlaCar then expanded outside Europe, addressing the Indian, Mexican and Brazilian markets. Note that the company's biggest market in 2017 will probably be Russia.

BlaBlaCar first raised money from a business angel in 2009 for an amount of 600K€, followed by a second round of 1.2 M€ in 2010 and a third round of $10 million in 2012. In 2015 and 2016, the company raised $300 million from venture-capital firms. Most of the investment came from US investors even though the company does not operate on the US market and does not seem to intend to address this market in the future.

BlaBlaCar is now the world's largest long-distance ridesharing community. It has more than 25 million members across 22 countries. It is one of the European unicorns and is at the vanguard of the sharing economy.

To remain innovative and extend its market, the company has introduced new services were aimed at stimulating car sharing. For instance, festivals and concerts can create their own page to foster ride sharing to and from the event. The geographical expansion of the company might have reached a plateau since the CEO explains he is not convinced that there is a strong potential in the US and that other large countries like China are probably difficult to penetrate.

In 2015, Frederic Mazzella launched a movement to induce French entrepreneurs who have set up their company abroad to relocate in France. The company has been strongly pushing the French start-up scene. It originally rented office space in the premises of another French unicorn, Criteo, and is now passing on the favor by renting office space to another start-up, Devialet. As Nicolas Brusso notes, "Now you really have an [start-up] ecosystem [in Paris]. While the first generation of companies were very French, now you have a generation that thinks global or at least European from day one. The main change is the level of ambition."

Feedzai: Born in the EU, developed in the US

Francisco Veloso

In 2008, three friends with technical degrees from University of Coimbra in Portugal joined forces to create Feedzai. Nuno Sebastião was completing an MBA at the London Business School while working at the European Space Agency and put the challenge forward. Feedzai became his MBA thesis. The idea was to do 'something' with the technology that Pedro Bizarro had started developing during his PhD at the University of Wisconsin-Madison, and was currently working on as an Assistant Professor in Coimbra together with Paulo Marques, a fellow Assistant Professor. Pedro's algorithms were capable of processing massive amounts of data very efficiently in real time, what has been labelled as big data. Pedro and Paulo, had many international contacts, including at top places such as Carnegie Mellon University, where both spent time as part of the CMU-Portugal program. Nuno and Paulo also had a past entrepreneurial experience and thus a good orientation for what can be doable with technology in the marketplace.

The team was able to conduct high performance processing of very large-scale, very high throughput data loads, to produce business intelligence in real time. To gain a better perspective on the application of that knowledge they applied and were awarded over €1-M in financial support from the QREN program (EU structural funds to Portugal), to develop some of the original applications. These funds allowed the firm to be much more self-sustained in its initial stages, and therefore rely less on external capital, rendering its finances more stable than the typical start-up. In addition to EU funds to Portugal, and their own bootstrap money, the firm also benefited from small (€1.3 Meur) early stage investments by Portuguese VC firms.

One of the original opportunities was to apply the algorithms in the energy sector, including in the wind-energy industry. The perspective of development in this area led Feedzai to become incubated in EDP Ventures, the entrepreneurial promotion arm of EDP, a large international utility based in Portugal, which was also an investor. Other potential areas included fintech and telecommunications, where the firm did several pilot projects.

The most significant use case, which would become the basis of growth of Feedzai, was in the financial sector, in particular payment processing. Feedzai was invited to test its tools detecting payment fraud in a nationwide payment processor. The early results were encouraging, both in terms of the capability to detect errors better than the existing system, as well as with regards to the speed at which it was completed, allowing an effective real time decision, before the payment was processed. The testing continued and its success and future potential rapidly made the firm focus its efforts on further developing this use case. This certainly meant improving the tool, its reporting, capabilities, features, etc. But, given that there is only one processor in Portugal, it also meant the search for new international clients that could be the basis for development.

What has been so far a great Portuguese entre-preneurial story starts to turn to the US at scale-up stage. When considering the international expansion, the founders were considering two critical issues: where to find clients for the promising technology and how to acquire the financial resources that would allow the firm to move to its next stage of development. And the choice quickly became the US. First, there was the idea that banks and payment processors in Europe are mostly national and thus serving much smaller markets than an equivalent US firm; they were also seen as biased towards domestic solutions and firms. It was also more difficult to engage European VCs. They appeared to lack experience and comfort understanding and assessing Feedzai's technology. Moreover, once the objective in terms of market development became the US, it was also very clear that a US based VC would lend extra credibility to the firm, while helping to open local doors. And indeed that was the path chosen by Feedzai. US-based VC firms in the areas of big data and fintech were mostly responsible for the next rounds of investment, and its main target for business development became the US.

An ironic aspect of this path was precisely that one of the significant investors was SAP ventures, but the unit based out of California.

After over a year of many contacts and attempts, as well as smaller contracts, the first large international clients started to appear, precisely payment processors. Feedzai is now working with FirstData, one of the largest payment processors in the world, and has among its investors Capital One and Citibank. It has since also started working with a large processor in India, as well as a variety of top 50 US-based retailers. A complementary area of development has been its solutions for retail fraud prevention. Its business focus on the US has created important pressures for the firm to move its headquarters to America. And, while the CEO, marketing, business development and sales are now based in the US, the HQ and research/engineering are based in Portugal in three locations (Coimbra, Lisbon and Porto).

More recently, the firm started to develop more aggressively the European market, trying to court processors and retailers to adopt its solution. But, as one can readily conclude, this only happened after its initial grounding in the US. Feedzai is having significant traction in markets such as UK and Spain, while also engaging with strategic investors in key European markets such as Germany or France. Hopefully, after that we will trickle down to other European Countries.

Abris-Capital: investing in local champions in the emerging markets of Central and Eastern Europe

Daria Tataj

Private equity is an important element of every successful entrepreneurial ecosystem. Early stage investors such as business angles and seed funds help start new companies. Venture capital helps start-ups grow. Private equity with investments ranging between 30 – 100 million EUR, provide both growth capital and know-how to scale-ups taking a chance on emerging champions to become global market leaders.

The lack of sufficient private equity funding has been hindering growth of the entrepreneurial ecosystem in the emerging markets of Central and Eastern Europe. The predominant provider of capital has been government agencies accounting to 36% of all private equity raised in 2015 in the CEE region. The lack of high-risk funding has been especially salient in the case of growth capital targeting the mid-market companies called scale-ups. The CEE region is considered one of the most overlooked regions for the private equity investment.

Challenged by the lack of local or European financiers, fund managers active in the region have resorted to international investors, notably from the United States and elsewhere. If the current situation continues, many of most successful local champions will not realize its full potential, and that a growing number of companies will be bought out by non-European capital.

While there are some investment opportunities in the emerging markets of Central and Eastern Europe, not many businesses meet investment requirements of trade buyers or IPOs. Good companies for sale are a rare good, says Neil Milne, Managing Partner and co-founder at Abris-Capital. 'Our core business is straight-forward', says Milne, 'we turn great companies into investment-ready companies'. The growth strategy in most cases is simple: market consolidation, or value chain integration, or expansion of operations across borders and into new market niches. If successful, these local champions are prepared for a trade sale or an IPO within 3-5 years.

Abris-Capital is an example of independent private equity funds in the Central and Eastern Europe. The fund was created by a group of private equity professionals, partly by luck, partly by strategy, says Paweł Gieryński, a senior partner and CIO at Abris. In 2007 Advent International, a country affiliate of Copernicus took a strategic decision to exit mid-market niche and focus on larger transactions. 'We were faced with an existential decision: scale down or become what Advent was for the Region', says Gieryński. The second choice was followed as the mid-market niche was half-empty and the competition was low.

The decision to scale-up coincided with the decision of the Harvard University endowment fund to increase its exposure to CEE region. The funders of Abris Capital managed to convince Harvard to become its first 100 million EUR cornerstone investor, gaining not only funding but also credibility. Additional 220 million EUR followed from some other US university endowments and pension funds from Europe and Australia. With Abris II fund closed in 2012, the fund manages over 770 million EUR of committed capital, making it one of largest mid-market funds in the CEE region, alongside of Enterprise Investors and Innova Capital.

Up to date, Abris has invested in 20 companies in Poland, Romania, the Czech Republic, Serbia, and Ukraine and exited eight of its investment. With offices in Warsaw and Bucharest, its eight partners provide geographical coverage of the whole region, speak local languages, and can share their operational industry experience.

While the strategy and operations is a management's business, governance is surely the business of fund managers. An injection of private equity capital opens a period of radical change for every company. Absorbing it often poses challenges at many levels. Professionalization of shareholders governance is key to capture success, as it includes regular shareholders meetings, quarterly monitoring and business plan adjustments, ensuring high level of financial reporting and controls, optimizing cost of capital and strengthening management capacity, mitigating diverse risks, and balancing interests of different shareholders and stakeholders.

In 2015 the private equity market in Central and Eastern Europe was valued at around 1.6 billion EUR with over 50% transactions concentrated in Poland. The market segment of mid-size growing companies attracted over 98% of all transactions in terms of value. Almost 70% of fund managers declare that the attractiveness of the mid-market market segment will grow. Still there is a growing gap between available growth capital and investment opportunities, according to Milne, and it will take around 10-15 years for the market to balance off offering superior returns for the incumbents.

There is a wealth of tacit knowledge at Abris how to help local champions grow. With low competition and high supply of local champions and entrepreneurial talent, Abris can target ambitious returns on its investment as in the case of Alumetal, an aluminum producer which was successfully floated on Warsaw Stock Exchange in 2015, or Green Group, in which the fund invested over 40 million EUR in 2016.

Low availability of private equity, growing investment opportunities especially in the mid-market, and high barriers to entry, have created a good competitive advantage for incumbents like Abris. However – from a policy perspective – if there were more fund managers interested in the CEE region, the entrepreneurial ecosystem would develop faster. This means that there would be even more successful companies creating more jobs and spinning off the local economies for the benefit of all.

Adamed Group

Daria Tataj

The biotech, healthcare and pharma industries undergo a paradigm shift. Colliding demographic trends, new technologies, bid data, business model innovation, and a myriad of entrepreneurial ventures challenge incumbents in existing markets and create new ones. Adamed Group is one of the challengers and incumbents at the same time facing both unpredictable trends, radical innovations and unexpected growth opportunities.

Adamed Group is one of the largest biotech/pharma companies developed in the markets of Central and Eastern Europe. It has a family business. Entrepreneurial genes showed up when Adamkiewicz, the grandfather, opened a small poultry business in communist Poland. His son, Marian, a medical doctor, started Adamed in 1986 to cater products used by the gynecologists. Marian's son Maciej, also a medical doctor, joined the family company in 1996 and since 2000 is its Chairman. Maciej's wife Małgorzata, also a medical doctor is the company's CEO. Their son Michal stands behind the company's new educational project.

In over thirty years, Adamed has grown from a start-up producing generic drugs and medical equipment into a company with over 242 million EUR annual revenue projected for 2016, 250 new generation products, 1600 employees and presence in 60 countries around the world including representative offices in Russia, Spain, Kazakhstan, Czech Republic, Ukraine and Slovakia.

Like in many other cases, the company's success is tightly connected to the transformation of the whole region. Accession of Poland to the European Union in 2004, stable political framework, the single market opportunities and open competition, predictable legal regime with clear intellectual property protection, and public funding to expand research and development activities were some elements which fuelled the company's growth. However, while many companies shared the same opportunities, not so many were successful in turning them into sustainable global business. What made Adamed succeed?

What matters for a success of most start-ups is an ability to challenge incumbents operating in a growing and lucrative market. Dominated by state-owned companies and large pharma, Adamed had to find ways to challenge their position. It decided to develop its own generic drugs, improve them and offer at a fraction price to millions of patients. Quick and early success came with 'Furagina' (1991), a drug that offered treatment of urological diseases, which became to dominate the Polish market and soon after the markets in Central and Eastern European countries. This was also the case with Amlozek (1998), based on Adamed's own patented formula for the development of amlodipine, a substance in a drug for hypertension, was successful in competing with Norvasc by Pfizer.

Turning commercial success into business success depends on an ability to cater to the growing market demand. Expansion of its production capacity was another critical milestone for Adamed. The company built its own manufacturing site and grew also by acquiring two companies in 2010: Polfa Pabianice, a state-owned pharma company and Agropharm, a leader in non-prescription drugs and nutrition supplements. In 2016 its production capacity reached 1.5 billion tablets per year.

The in-house research and development as well as licensing in and out have become the growth strategy of Adamed and an inherent part of its business model. In 1999 Adamed created the Research and Development Department to work on innovative medicines building at the meantime two manufacturing facilities. The company initiated its first scientific consortium with the Jagiellonian University in Cracow in 2005. Ten years later, 150 scientists and 17 universities and research institutes in Poland and abroad work with Adamed Group on innovative research projects, developing innovative solutions, improving existing therapies, conducting activities to promote healthy lifestyle and wellbeing. Since 2001 the company has invested around 215 million EUR (900 million PLN) in their own research and development activities and registered 94 patents. In 2016, Adamed Group opened a brand-new R&D facility in Pienkow next to Warsaw.

One of its most innovative projects was co-financed by the European Regional Development Fund. Its goal was to develop a new biotechnological, targeted anti-cancer drug. Out of many tested molecules designed by researchers at the Adamed Group within ONCO-3CLA program, one was selected for clinical development within project ONCOTRAIL and implemented in consortium of leading medical research institutes in Poland and financed by the National Center for Research and Development within STRATEGMED program.

In 2016 the company entered a new market segment: telemedicine services. In partnership with Silvermedia, a leader in the creation of tools for medical process management, Adamed Group launched Medivio, the first in Poland certified telemedical clinic. It enables remote communication between doctor with patients, diagnosis, data collection and processing, monitoring of treatment and education of doctors and of patients.

Long-term thinking and willing to nurture talent and next generation inventors, Adamed Group has set up its Foundation to support research, development and education in the field of science. It was launch to help young students grow their passion but also evolved into a sort of open innovation platform engaging thousands of people into a scientific discussion and mutual learning. Its main program is ADAMED SmartUP that targets high-potential students and offers them individual learning path through its innovation camp then followed by 10-month mentorship program with experienced experts. Participants with the greatest potential get a chance to receive a special scholarship, tailored to their needs. In the first two editions of the program, it registered more than 8.7 thousand participants, educational platform recorded 123,000 unique visitors and the website 466,000 page views, and the Facebook page over 25 thousand fans. Engaging communities into user-driven innovation will surely help Adamed stay on top of emerging consumer needs and trends.

Eataly – Design-Driven Innovation in Services

Roberto Verganti

Eataly[144] is an Italian-owned, globally operating market/mall chain that has proposed a new way of how food is experienced. Unlikely to be classified according to traditional sectors categories or market segments, Eataly is partly a grocery store, partly a set of restaurants, partly a culinary school, partly a bookstore, partly a supermarket. All arranged around its unique value proposition: a learning experience around food. In a global context where traditional grocery stores compete on price, and sales are increasingly moving online, Eataly proposes its unique physical experience, which comes with a significant premium price. Its vision, put forward by its founder, Oscar Farinetti, can be considered as a spin-off of emerging cultural movements on new food habits, and especially from Slow Food, the radical circle of promoters of “good, clean and fair” food, to which Farinetti was closely connected.

Oscar Farinetti was born in 1954 in Alba, a small town in the core of a territory rich of food traditions. He was the son of a baker, who opened a supermarket near Alba, with the name of UniEuro Market. While attending University of Economics and Commerce in Turin, Farinetti met Carlin Petrini, who would later become the founder of the Slow Food movement. In 1977 he moved back to Alba to help his family business. After being successful in the market of appliances, he sold his company in 2002 to the British firm Dixons and set up Eataly.

From 2003, Oscar Farinetti started to take contact with the people he met with the idea of create his Eat Italy, and did this using the batch of contacts he had obtained through his friendship with Carlin Petrini. A strategic support team from Slow Food provided him with expert advice to identify and select small food suppliers, and on training in-store staff.

144) www.eataly.net

From 2003 until 2005, he started to travel the world to explore alternative concepts. He studied the fish market of Tokyo, KaDeWe at Berlin, Auchan at Eurodisney, Iper near Milan, Saluhall at Stockholm, Harrods in London, Grand Epicerie de Paris, Carrefour, Coop, Ipercoop, trattorie, Michelin's guide restaurants, Peck in Milan, Tamburini- Antica salsamenteria in Boulogne.

It led him to understand the main values that had to characterize Eataly, his new creature: 'These values were Prestige, Informality, Honesty, Smartness, Irony, Pride. All these values enclose the whole sales cycle, but they weren't put together, until now they were considered mutually exclusive. (Farinetti, 2008).

Eataly opened in Turin on January 26th, 2007 and success was immediate with stores opening, in Milan, Genova and Bologna in Italy and Tokyo and New York abroad. The breakthrough retail innovation introduced by Eataly enabled it to thrive in an industry where traditional retail stores, especially brick and mortar, struggle to survive. Today Eataly counts about 20 stores in the whole world and in the most exclusive locations, it is valued at more than € 1.2 billion with an annual growth of 33 %.

Eataly is a benchmark example of how growth from innovation can be enabled by different drivers than traditional technological innovation. The drivers that underpin Eataly's breakthrough are new entrepreneurial vision, based on a novel customer experience, a brand-new value proposition and business model, design of its stores, communication and services, and internal organization processes, human resource practices and supplier agreement contrasting sharply with traditional retail businesses.

4.4 PRO-INNOVATION REGULATION[145]

Christopher Tucci

4.4.1. INTRODUCTION

The interlink between regulation and innovation is complex and subject to many questions, including who should regulate—member states, the EU, or international / global bodies. New types of innovation challenge the established conception of regulation—business model innovation, the collaborative economy, design innovation, etc. Previously, structured governments interacted with structured companies; now, a decentralized system involving governments, firms and citizens with a high amount of mobility across jurisdictions is emerging and complicating regulatory interactions.

This section presents some of our reflections on "pro-innovation" regulation: what it means, why the European Commission might need to further develop and promote this concept, and some general principles for how to approach it. The analysis assesses the requirements for applying regulations, highlighting the importance of an innovation principle which requires that whenever the EU's institutions consider policy or regulatory proposals, the impact on innovation should be fully assessed and addressed. There are illustrations of cases from the sharing economy, from the energy sector, and summarize lessons from regulatory experiments in the US.

The changes we are facing are not just linked to pure digitalization; they are also about self-driving vehicles, CRISPR, blockchain, Uber and Airbnb platform-based business models, etc. These technologies are part of a "convergence" trend that enables companies to move across or compete in multiple sectors and also possibly build new business models. Thus, a sectoral approach to regulation may become irrelevant and possibly too slow to react. In the longer term, there is a need for a more

[145]) *This section has been prepared on the basis of inputs from RISE experts from the Open Innovation Working Group: Daria Tataj, Anders Hvid, Delphine Manceau, Stephan Morais, Christopher Tucci, Francisco Veloso and Roberto Verganti; with EC input from Katarzyna Bitka, Wolfgang Burtscher, Ciara Phelan, Gergely Tardos, Ramona Samson and Johan Stierna; and experts Alex Gaschard, Bolko Holhaus, Andrea Renda and Hans-Gerd Servatius. The lead author and coordinator was Christopher Tucci.*

horizontal, systemic view of innovation, rather than sector-specific thinking. In the short to medium term there is also a need to think about how best to work to make the existing regulatory and policy structures as innovation-friendly as possible.

4.4.2. ON REGULATION AND INNOVATION

A regulation is a "law that controls the way that a business can operate, or all of these laws considered together."[146] In this chapter, "regulation" is considered mostly in its broad sense, as the set of laws that respond to aims of the policymakers, notably to correct market failures, to pursue goals of equity and fairness, as well as long-term policy goals such as those defined on a strategic level[147] (Europe 2020, the ten priorities of the Juncker Commission). Regulation often works via rule-making, giving incentives for desirable outcomes, or punishments for undesirable. Regulation can be legislated directly (primary) or, more often, delegated to governmental bodies empowered to make rules (secondary legislation). Regulation can also work through the conditions of public procurement and access to large public contracts (with specific environmental regulations for public contracts, for instance).

Pelkmans and Renda (2014) define four stages of the regulatory process: agenda-setting, legislation, compliance and enforcement, and six main types of regulatory intervention: regulation through information, self-regulation, co-regulation, standardization, market-based instruments, and prescriptive regulatory actions. The first phase within the regulatory process can be defined as the "Agenda-Setting phase," in which relevant preparatory work is done, in the form of communications, studies, or "umbrella" regulations. The legislation phase includes the regulatory process within the competent institutions, resulting in adoption of regulations, directives, and implementing acts. In the compliance and enforcement stages implementation is monitored and measures are taken in case of non-compliance.

Regulation through information and self-regulation are the softest available measures, building on cooperation with the concerned parties. Co-regulation merges the advantages of self-regulation with the clarity of an established legal framework. Standardization implies joint work on the development of standards between policymakers and various industry players. Market-based instruments provide financial incentives for desirable behaviours, and disincentives for undesirable ones. Finally, prescriptive regulatory measures are the heaviest form of regulatory intervention, notably through traditional "command-and-control" policies and rigid requirements for the regulated bodies.

The OECD (2005) distinguishes between four types of innovation: product innovation, process innovation, marketing innovation, and organizational innovation, and Massa and Tucci (2014) add to this mix "business model innovation" (how the organization creates and captures value). The link between regulation and innovation is complex and subject to many questions, including (1) who should regulate—member states, the EU, or international / global bodies? (2) how can bottlenecks to innovation other than lack of funding be identified?[148] and (3) what specific steps can the EU pursue to improve regulation?

It is very important to note that regulations are not necessarily negative, or a barrier to innovation in and of themselves (see Green Group case in Box 3).[149] There are many areas where regulation is necessary and important, such as environmental protection, public and animal health, and consumer protection, and there is a large body of evidence in the literature showing how regulation has induced innovation, particularly in the environmental sector.

However, in recent years some fundamental assumptions about regulation have been challenged in some regulatory domains.

- *Regulations are supposed to protect consumers*. In many cases, regulations were originally developed to protect consumers, but over time, incumbent companies (companies already competing in an industry) in certain sectors may use regulations as a shield to prevent competing technologies from gaining a foothold. This has been said to have happened in the energy sector in certain cases (see box below) and

[146]) *Cambridge Business English Dictionary, 2016.*

[147]) *Labonte M. (2010)*

[148]) *See, for example, RTD SWD Better Regulation for Innovation-Driven Investment at EU Level.*

[149]) *See also, for instance, Ashford & Renda (2016), p. 26.*

therefore the original intention of some regulations has been modified toward protecting incumbents rather than consumers, who could benefit from better service or lower prices if competitors, perhaps with different technology, were allowed into the market. Regulatory capture[150] has been specifically noted as a common reason behind this phenomenon, notably through concentrated interest of established industry in favour of regulation, and dispersed benefits of allowing new entrants among the citizens.

- *Specific identifiable governments interact with and target specific identifiable companies.* In the past, the specific entities on both sides of the regulatory equation were known quantities. Firms were rooted in a geographic area with services (such as beauty salons or dentists) occurring in the same area and (slow) transportation was required to ship products (such as manufactured automobiles) elsewhere. Thus local jurisdictions knew which companies were in their purview and likewise the companies themselves knew which jurisdictions they were operating in. What has changed in this area is that due to Internet infrastructure and digital delivery, firms (for one example out of many, peer-to-peer file sharing services) may operate well outside a (or any) geographical jurisdiction yet be able to penetrate those remote markets easily.

- *Regulators know the regulated issue better than the firms involved*. Regulators have often been drawn from experts in certain sectors and were thus able to understand the situation of consumers or employees as well as trends in those sectors (for example, taxis, car rental companies). However, in recent years, rapid technological change has made it more difficult to keep up with new business models that might challenge the status quo. Information asymmetry, widely recognized as an issue between the regulator and the firm,[151] is increasingly a challenge with digital companies and new business models. For example, the emergence of ride-sharing platforms (see box below) may have caught some regulators off guard in terms of licensing drivers, restricting supply, or collecting taxes.

- *Regulators know the regulated issue better than the "crowd."* Consumers may once have been considered a homogeneous mass with quality enforcement left to regulators to protect them (for example, hotels). However, more recently, due to Internet platforms, online reputational measures that utilize the "wisdom of the crowd" may be quicker and more accurate than relying on traditional regulatory processes for identifying and sanctioning poor quality[152] (for example, house sharing ratings or hotel ratings online that consumers browse before making bookings).

- *Regulations are meant to be decided once and last for decades.* It is no secret that successive technological generations seem to appear more closely spaced than in the past (for example, automobile emissions technology, music formats, mobile phones) and therefore the pacing and timing of regulations that were applicable to prior generations may no longer be appropriate when new generations are commercialized at a quicker pace.

- *Regulations are sector-specific and each sector can be isolated by controlling the way business operates in that particular sector.* Beyond digitalization, self-driving vehicles, CRISPR, blockchain, etc. are part of a "convergence" trend that enables companies to move across or compete in multiple sectors. Thus a sectoral approach to regulation may be becoming irrelevant and possibly too slow to react. In his analysis of the impact of regulation on innovation across sectors, Blind (2012) proposes that impacts are heterogeneous across sectors, concluding that companies are more innovative under flexible and incentive-based regulations. In the longer term, there is a need for a more horizontal, systemic view of innovation, rather than sector-specific thinking.

Overall, the fact that information technology is now pervasive and leading to "convergence" between sectors as well as rapid diffusion of new technologies, business models and platforms are putting pressure on prior notions of regulation. In particular, ignoring the above may be causing firms to chase jurisdictions with more lenient philosophies toward regulation. Normally, trade

150) *Dal Bo (2006)*

151) *For instance Laffont and Martimort (2002)*

152) *Thierer et al. (2015)*

laws could be used to prevent firms from racing to the regulatory bottom, but in the case of information technology-based platforms, it is difficult to prevent the platforms from invading the less-regulated jurisdiction.

There are other cases where legislation in one jurisdiction may allow activity that is forbidden in another, while the resulting product or service can be (legally) made available in any jurisdiction. An example of this is in Text and Data Mining (TDM), where a company operating in a jurisdiction that allows TDM can utilize the procedure to create a product that can be sold into a jurisdiction that does not allow innovative companies to use TDM.

Some of the changes are related to digital migration, such as crowdfunding, fintech in general (machine-based advisory, peer-to-peer transactions, digital payments, cryptocurrencies, etc.), collaborative / sharing economy (trading on excess capacity of crowd), data protection, and 3D printing. However, as mentioned above, other changes we are facing are not simply linked to digitalization. Technologies such as CRISPR (clustered regularly interspaced short palindromic repeats, which may be used for genome editing) may also challenge values and ethics. Europe needs people who understand technologies and the regulatory environment to drive change; and regulation should serve as a forum for building the discussion.

Faced with all these developments, incumbents are fighting for their lives, also using regulation to block new technologies (see below). These technologies also cut across sectors, thus a sectoral approach to regulation may be less relevant now. Big players such as Google can and do ignore sectoral boundaries.

CASE 1: CARAMIGO AND RIDE SHARING

The "collaborative economy" in which individuals offer their own personal spare capacity to rent mediated by IT platforms is thought to be a hotbed of spontaneous innovation, in which firms experiment by launching platform based services to the market. CarAmigo is a platform connecting car owners and drivers, adding insurance, screening IDs, confirming ownership, etc. It currently offers 500 cars in Belgium, and is about to expand to Eastern and Southern Europe.

CarAmigo applied for a fiscal ruling to the fiscal authority of Belgium to avoid tax problems for people who share their own personal vehicles. As a response, rules were fixed for "reasonable use" (not as a professional activity/main source of income) of CarAmigo representing a ceiling of two cars per person rented for a maximum of 60 days; if met, this was not considered professional income. Tax rates were set at 25 % but with expense deductibility of 15 %. CarAmigo management feels that companies like them could benefit from harmonization of taxation at the EU level; however, they also understand that this is very complex politically.

CarAmigo is a good example of a company working outside a fixed sector; this raises a question: should there be a sector-specific regulation? And the answer is perhaps not, because old definitions of industries often do not hold anymore, thus making it difficult to identify and regulate the target organizations.

It is also an example of possible "delegation" of regulations, in which sharing economy platform companies, such as car-sharing services could be delegated to compliance with laws and regulations, such as collecting taxes.

Finally, it is an example of a company proactively engaging with regulators and raises an important question about the role and responsibility of firms in terms of engaging with the regulatory process. This "co-regulation" effort certainly has the potential to be successfully emulated by relevant other businesses.

Source: Interviews with expert.

CASE 2: ENERGY TRANSITION

In contrast with collaborative economy innovation, innovation in the energy sector does not often happen spontaneously, because standards are not agreed upon and the innovations developed often interact with a more static infrastructure. Between the two extremes of car sharing and energy, there is a whole spectrum of different patterns of spontaneous market experiments.

Energy is already a highly regulated market, with good historical reason in that infrastructure needs to be of high quality and supply of electricity needs to be secure. However, it is also possible for incumbents to use the regulations to shield themselves from the impact of innovation rather than experimenting with new technologies and business models. In the case in which there is both an innovation-unfriendly utility and an overactive regulator, it is possible to end up in a "fortress" scenario, where incumbent power continues until an outside player enters with enough scale to disrupt the system. In cases in which there is a proactive start-up and some liberty on the part of the regulators, one could observe interesting outcomes. Is it possible to move away from the idea of regulating to solve a problem and move toward regulation that supports the development of something new? One problem is the development of new technologies, and whether regulations can keep up with the technology; flexibility would have to become a norm.

The point is that in the short term, this could be a highly effective strategy on the part of utility incumbents, but they are facing a risk of having their business models "disrupted" by the big digital players. Currently, many traditional utilities have a narrow perspective: they focus on producing energy, etc., and do not consider the added value of energy efficiency. Utility companies could, for example, co-generate with users and trade some of the capacity. However, these new business models would require experimentation on both the part of regulators and the utility companies themselves. In other words, current regulations may not be helping utilities in the longer term.

Source: Interviews with expert.

CASE 3: GREEN GROUP – A CIRCULAR ECONOMY BUSINESS FROM ROMANIA

Daria Tataj[153]

Open innovation is one of the key drivers of the circular economy: a term used to describe a growth model engaging citizens in a process of creating value in a balanced, sustainable and environment-friendly way. Driven by environmental concerns, behavioural shifts and climate change regulations, the waste recycling sector has been offering good business opportunities, which attract private equity investors.

While most examples of the circular economy usually originate in Western Europe, there are more and more local champions in the peripheries of European innovation networks driving innovation in this area. This is the case of the Green Group, the leading recycling business in South-Eastern Europe with its main operations in Romania where the company owns 60% share of the Polyethylene terephthalate (PET) market, 50 % share of the electrical and electronic equipment waste recycling market and is the most important recycler of lamps and batteries. It is also ranked as the 4th largest polyester fibre producer (PSF) in Europe and may become the second largest after the installation of a fourth fibre line in 2017.

In early 2016 the company raised over 48 million EUR from Abris-Capital, one of the largest private equity funds in Central and Eastern Europe, with the purpose of continuing its national and regional expansion.

Romania has the lowest recycling rate in the EU. Only 5% of the waste produced is recycled versus 29 % on average in the EU and a target for all MS of 50 % by 2020[154] . The legacy of the water recycling sector, which had a monopoly under the communist system, marks current public-private partnerships with questionable levels of transparency. A system, in which companies, such as beverage or producers of home appliances, pay a fraction of their turnover to specialized non-profit organizations for waste collection and recycling, through Extended Polluters Responsibility (EPR) schemes: a validated model at EU level but implemented without a proper control mechanism to work efficiently. Public policy with a low landfill tax does not incentivize change either. However, the situation will

153) http://ec.europa.eu/environment/waste/target_review.htm, viewed 11 December 2016

154) See http://ec.europa.eu/eurostat/documents/2995521/7214320/8-22032016-AP-EN.pdf and http://www.eea.europa.eu/soer-2015/countries-comparison/waste#note5 have to change as Romania will have to decrease its landfilling to 50% by 2020 when the derogation period from EU regulations ends.

This case provides good evidence on the role of policies in driving innovation and growth.

Quite unusually, the business was started by a foreigner – Mr. Clement Hung, born in Taiwan, who had 24 years of experience in the plastics industry in Asia and in Europe. In 2007 he decided to settle in Romania, a "beautiful, welcoming country with vast business opportunities and low level of mountains", as he says, comparing it to his homeland.

Since 2010 the Green Group has invested 60 million EUR and more than 10 million EUR investments are planned for 2017. In this period the number of employees has almost doubled, reaching 2,300. The real value of Green Group is generated by its quite special business innovation model based on a system called SIGUREC[155] which was 50% financed by the Norway Innovation Fund. Its competitive advantages include integration between PET collection, recycling and fibre production which is unique among the European producers. It gives the Group control on the raw material procurement and at the same time increases its quality keeping the costs at the level of Asian competitors, well below European pricing.

Green Group's business model links a few core components: a fleet of 115 trucks, a network of 46 container-size boxes distributed around the country equipped with software enabling segregation of waste into different waste streams, 38 hubs/ processing points covering the entire country, an app allowing trucks to operate almost as 'an UBER of waste", and a smart incentive system engaging citizens and supermarkets in the waste collection process in a reward system based on vouchers which can be either donated to a charity, or used as a discount coupon upon a next purchase in selected supermarkets. The waste collection method is the most important component of the Green Group's business model.

Collecting waste is not a profitable business on its own. However, in a vertically integrated value chain it brings significant costs savings. The SIGUREC innovative process and business model is based on driving costs down by engaging citizens in the waste collection with segregation as a prime example of the circular economy.

Abris-Capital appreciates the entrepreneurial drive of Mr. Hung, who is sometimes referred to as the "Elon Musk of Eastern Europe". He was kept in the key role of CEO of the company. The fund manager believes that good fundamentals, multiple income streams, a competitive cost base and the experienced management team should enable him to meet the expected returns on exit. The fund plans to strengthen the company's financial management and business processes preparing it for a trade sale or an IPO within 3-5 years.

Under the new shareholding structure, Green Group is well positioned to roll out faster its business operations capturing significant market share in Southern and Eastern Europe. This is indeed aligned with Mr. Hung's dream: increase the capacity by 42% to 75 thousand tons per year and become the 2nd largest PSF producer in Europe by 2018. Paradoxically, only access to waste seems to be a bottleneck: to work at its full capacity, Green Group needs to import over 40% of waste it recycles from neighbouring countries. Not surprisingly, waste is referred to as 'green gold' at Green Group.

Source: Interviews with expert.

4.4.3. GENERAL PRINCIPLES FOR APPLYING REGULATIONS

In the context outlined above, some general principles emerge:

The first and most critical is to consider an Innovation Principle, which is a philosophy that regulators might use to actively consider the innovation implications – or possible unintended innovation consequences – of all new regulations and policies in their design or review phase (before deciding on, or updating, them).[156] An EPSC note earlier this year[157] demonstrated that there is already an implicit innovation principle within the treaties, thus justifying a further implementation of this principle.

If Europe wants to host the most innovative companies with new ideas and global ambitions and if it wants to be open—and not only in theory—to new business models, even if they disrupt incumbent business, that

[155]) *http://www.sigurec.ro/en/*

[156]) *Council conclusions on the Research and Innovation-friendly regulation at its 3470th meeting held on 27 May 2016.*

[157]) *https://ec.europa.eu/epsc/file/strategic-note-14-towards-innovation-principle-endorsed-better-regulation_en*

will require hard work by regulators.[158] As underlined in the Staff Working Document[159] on *Better regulation for innovation-driven investment at EU level*, the regulatory environment is more and more a critical driver for the success of innovation in Europe. The breathtaking pace of innovation as discussed above also puts the regulatory framework under pressure.

An innovation-friendly regulatory framework is not a one-off act, but a constantly iterative process, responding to changes in the innovation ecosystem. What matters is the way regulation is designed and applied. An Innovation Principle could anticipate the potential innovation impacts of policy or regulatory proposals and allow them to be addressed; allowing Europe to build a regulatory framework that meets the primary aims of relevant legislation and boosts the capacity for innovation.[160]

Flowing from this general principle of considering impacts on innovation, there are a number of sub principles that would complement and support the implementation of an Innovation Principle:

Speed of Regulatory Process: To develop a regulatory process that is fast enough to follow technological innovation that is not only accelerating but invading all sectors, from manufacturing to IT to finance. The regulatory process could also apply to norms or standards. Companies often underline that norms are a major obstacle to innovation because they are based on existing products, are very slow to change and are very industry-specific and product-specific (and thus not adapted to hybrid products and even less to cross-industry innovation). They are also a major obstacle to innovation because of the uncertainty they create until they are stable, preventing companies from investing massively in a new technology until they are convinced norms will remain consistent over time. It is difficult to have both fast and stable regulations and norms, but these are key objectives to stimulate regulated innovation. According to Madelin (2016, p. 14), the key is in agility, especially in the Agenda-Setting stage of the regulatory process, where instead of choosing between "wait and see" or "do something now," Europe can instead offer to proactively learn about new technologies' business implications and then decide how to proceed. In particular (see Box 3 below), there should not necessarily be a conflict between the Innovation Principle and the Precautionary Principle.

Consistency across Europe: A large market such as Europe only functions if the regulation is nearly identical across all countries. Currently there are large inconsistencies across countries, for example fintech in the UK versus France. Lack of consistency creates both tensions between countries inside the EU (and a race to less regulated environments) as well as a push for innovators to move to the US (or other places), where the regulations are much more homogeneous or flexible.

Leanness of regulation: Regulations should be "lean" as otherwise innovative companies will be overwhelmed with legal burdens. Regulatory processes must be quick to adapt. In order to embed flexibility into regulation, there is a need to differentiate between early stage and later stage regulatory approaches to innovation; the lifecycle of the innovation is a dimension that has to be taken into account for the regulatory process. One principle is the idea of the "regulatory sandbox," in which firms can experiment with new technologies and business models as long as they are under a certain market size threshold. They can ask for "innovation deals"[161] in which uncertainty may be reduced or barriers to innovation may be removed if justified.

Outcome-based Regulation: There is more scope for innovation when regulations govern outcomes rather than processes. Any regulation should focus on the outcome and not on the process of how to achieve that outcome, i.e., the regulation should be technology agnostic. For example, a client of a bank needs to be

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158) Madelin, R. and Ringrose, D. (ed) (2016), Opportunity now: Europe's mission to innovate, p 39.

159) https://ec.europa.eu/research/innovation-union/pdf/innovrefit_staff_working_document.pdf

160) Pro-Innovation Regulation in Insight Articles' in Madelin, R. and Ringrose, D. (ed) (2016), Opportunity now: Europe's mission to innovate, p 90

161) Innovation Deals is a pilot scheme launched in 2016 under the Dutch presidency aimed at helping innovators with promising solutions to environmental issues to navigate perceived regulatory challenges to bringing their ideas to market. See https://ec.europa.eu/research/innovation-deals/index.cfm.

identified before s/he can open an account, the way this is done should not be regulated in details. (In Switzerland, the video identification rules are 20 pages, in Singapore three paragraphs.) This is already the case also for instance in the "New Approach" to standardization in the EU.[162]

Holistic Consideration of Cross-sectoral Implications: As mentioned above, IT companies, among others, can and do ignore sectoral divisions. Furthermore, some technologies cut across several sectors and it may not be obvious which sector they "belong" to. An example would be the use of robotics and artificial intelligence (AI) as applied in different markets. There is no specific law governing their use in Europe and they have uses in many different sectors (agriculture, health, transport, security, etc.) and it is often unclear under which rules they should be categorized. Are they medical devices, machine tools, vehicles, or something else? Seeking to understand how regulations in a cross-cutting technological area might have unintended consequences or feedback effects in a different area might help shape regulations in such areas.

Data Protection and Privacy: Legislation should tackle data protection and privacy, which is conceived of differently in different countries. More transparency may be beneficial (e.g., which data are collected is clearly shared with customers) and opt-in may be preferred to opt-out (i.e., the user has to actively agree that his or her data are collected).

Finally, regulation is about compliance and perception, and thus it needs to be simple, consistent, flexible, and well-communicated. The USA is often taken as a benchmark for assessing the way things are done in Europe. Some important reference points on the principles above drawing on the experience in the United states have been compiled in a recent study[163] commissioned by the European Commission (see box). In order to ensure that the regulatory process keeps up with technological development, the Federal Trade Commission (FTC) for instance takes a case-by-case approach to new technologies (recently dubbed "regulatory humility").[164]

162) Pelkmans & Renda (2015)

163) Renda, A.(2016), Regulation and R&I Policies. Comparing Europe and the USA

164) See Ohlhausen, M. (2015), Regulatory Humility in Practice, at https://www.ftc.gov/system/files/documents/public_statements/635811/150401aeihumilitypractice.pdf

Other tools, as listed by Renda (2016, p. 22) include a "'prudent vigilance' or 'regulatory parsimony' approach proposed by the Presidential Commission on Bioethics, which requires prudent vigilance and a proportionate, cautious approach to rulemaking and oversight; adaptive licensing or planned adaptation approaches proposed by academics on both sides of the Atlantic; and cases of negotiated rulemaking that ended up stimulating innovation, such as the 'Innovation Waivers' initiative and the 'Common Sense Initiatives' launched by the EPA."

On the leanness of regulation, some important conclusions stemming from comparison between EU and US show that the EU can be a leader in innovative approaches – for instance through the planned adaptive regulation in fields such as medicine. On data protection and privacy, some features of the legal system make the US a more enabling environment for innovation, notably the fact that in the US, privacy is considered a property right, whereas in the EU it is considered a fundamental right, making any trade in data more cumbersome in Europe. Moreover, the FTC in the US adopted a case-by-case approach to data privacy cases, making the system more flexible.

4.4.4. RECOMMENDATIONS

Based on the above, here are some specific recommendations consistent with the above principles that the European Commission might consider:

- As the IT sector embodies many of the challenges to the traditional approaches to regulation as discussed above, launch some experiments with willing member states, or regions, or even specific cities that might be willing to try and attract information technology clusters which could then serve as a test-bed for new ideas in regulation in addition to possible economic benefits. The following might be interesting to start with:

  - Delegated regulation or self-regulation[165], in platform markets in which it is difficult to enforce regulations on the consumer side of the platform, such as tax collection or reducing discriminatory practices in collaborative economy platforms. In this approach, the platform owner would for example withhold taxes from the asset owners once they

165) Cohen and Sudararajan (2015)

reached a certain level of income. Platform owners would be responsible for proposing solutions in collaboration with regulators.

  - Regulatory sandbox for highly speculative areas such as some aspects of fintech. In this approach, while firms are young or markets are small or non-existent, firms could ask for waivers or rule modifications, or official statements of non-enforcement while they test new products or services.

- Experiment with peer regulation, in an area in which the product or service does not pose a risk to consumer health and safety, such as personal services (barber shops, copy/print shops, or tax preparation services). In this approach, a ratings system with a robust verification system to ensure the integrity of the ratings could substitute for inspections and quality checks, or used as triggers for inspections.

- Form customer service units and digital services teams for companies participating in the above experiments.

- Work with the DGs to think about cross-sector approaches and how they might be integrated into Innovation Deals. For example, hypothetically, an innovator whose technology cuts across multiple sectors and feels that EU regulations in one or more of those sectors might be raising barriers could make a request to bring together the relevant DGs, regulators from different sectors along with other stakeholders to provide legal clarity and examine the possibilities under existing, relevant legislation. If an issue is found to exist, the parties could then work together to resolve the issue. Such an approach may reduce the possibility of growth in one sector being stifled by regulations on a different sector.

- And of course, continue with the European Innovation Council to help scale new ventures.

The experiments would have to last a certain number of years to be effective, have a piloting and evaluation mechanism built in for evidence gathering, and provide certainty to companies in those spheres.

The above recommendations would necessarily be completely independent of any upstream scientific financing schemes such as Horizon 2020, wherein some programming is sector-specific and others are more technology-specific. The regulation approach would attack cross-sectoral issues at the beginning of the commercialization cycle, which typically follows the research phase. This is not to forget that much of the existing system is structured in a sectoral manner and cognizance of this needs to be taken to meaningfully apply these principles in the short to medium term.

4.4.5. CONCLUSIONS

Traditionally regulators have regulated a problem, rather than being proactive. What would be preferable would be a mixed model, in which regulator and innovator are not opposed to each other but rather cooperate and are able to react more quickly to changes. Furthermore, parties losing due to regulation may need to be compensated or transition periods put in place, and clear communication is needed in case of a paradigm shift—contingency plans for users need to be in place in such a case.

Competition always comes from the future—thus there is a need to focus on creating conditions so that the next generations of value creation and capture can emerge in Europe. Potential target products and services that could be identified as priorities for a new regulatory approach could include transportation, self-driving vehicles, collaborative / sharing economy, fintech, cleantech, space and aeronautics, and biotech targeting major human diseases. In addition to targeting upcoming technologies and business models, regulators also need to find a way to take account of “future-proofing,” i.e., taking into account the possible needs of future firms, technologies, and business models. In any case, by following the principles outlined above, the regulators would be in the best possible position to manage the balancing act between economic growth and consumer protection.

Regulation in the US: Lessons for the EU

A recent study commissioned by the European Commission highlighted some positive and negative lessons that can be gleaned from the innovation/regulatory environment in the USA. Elements that might be considered interesting for Europe were:

A new US innovation strategy from a policy point of view articulated a wide range of options to encourage innovation. At one extreme (building the pipeline of long-term innovation projects), focused, relatively autonomous entities with wide latitude to make early stage investments in emerging technologies such as ARPA-E in the energy area is thought to be a success. In addition to that, a whole "open innovation" approach to government policy, including toolkits, digital services team within government agencies, and government innovation labs complete the package.

Horizontal regulatory policies in for example, competition policy, copyright, and data protection have produced much experimentation in the last decade in the US. For example, the proactive stance of the Federal Trade Commission in addressing data privacy issues quickly on a case-by-case basis seems to be allowing new business models to flourish.

Lessons from some US experiments that Europe may want to avoid:

Quick abandonment of the "precautionary principle" may be premature, in that evidence does not support the idea that on average the precautionary principle is bad. In fact, as mentioned above, precaution can be compatible with innovation. In addition, it is not true that the US is always less precautionary than the EU; in some cases, the US uses the precautionary principle more strongly than in Europe.

Over-reliance on negotiated rulemaking may have the unintended consequences of protecting incumbents and actually stifling innovation. Innovation deals should be used to improve regulation or reduce its uncertainty, not to reduce regulation itself. Further, too much negotiated rulemaking could actually diminish the likelihood of encouraging a truly radical technological or business model breakthrough.

Source: A. Renda (2016); R. Madelin (2016)

Chapter 5:

Conclusions and Policy outlook

CHAPTER 5
CONCLUSIONS AND POLICY OUTLOOK

Luc Soete

5.1 INTRODUCTION

This book started with a quote from Commissioner Carlos Moedas about the need to embrace change, and went on to analyze the macro- and micro-economic evidence on the complex ways in which science, research and innovation appear to have affected European growth, concluding with a Chapter on Open Innovation: more forward looking than driven from an analysis of the past, more sensitive to inspiring cases and weak signals than by large numbers and average behaviours. This gradual shift from the macro evidence to the detailed case studies illustrates the granularity red line throughout this RISE book. Starting from the macro-economic puzzles of low productivity growth where, with our current statistical and economic modelling set of tools, we seem not to be able to fully understand the present, and only barely apprehend what happened in the past, we appear in many ways particularly ill-prepared to address the future challenges in this complex area of science, technology and innovation.

Indeed, the fractures in the nature of research and innovation, which are characterizing current developments, imply that the past holds limited information about the future. Worse, a mere examination and extrapolation of data from the past might lock us into a path dependent process of a gradual falling behind, focusing on small, incremental policy improvements. For us, as RISE group of experts, there is rather a need to change trajectory, put forward new lenses on the fundamental changes in how open science, open innovation and open to the world innovation may impact Europe in different ways than thought about until now.

It is with this perspective in mind that this book focused on the concept of the 3 O's: the Open Science, Open Innovation and Open to the World framework proposed by Commissioner Moedas, as new framework guiding European research and innovation policy. It is clear, as highlighted from the start in the first Chapter that a new 3 O's framework raises major policy challenges. Each of the subsequent Chapters provided specific policy recommendations on how Open Science, Open to the World and Open Innovation could contribute to enhance a new dynamics in Europe. No need to repeat those here.

Rather, in this short final Chapter, we like to synthesize those policy recommendations along a number of general policy principles which we believe should govern Europe's future in science, research and innovation, and by implication European society's future. Presenting a vision explaining not just on why the current European knowledge economy doesn't deliver the promises it was meant to fulfil but also puts forward the broad lines along which research and innovation might become leading in mobilizing European society towards a better future[166]. The EU needs a paradigm shift from funding to investment in research and innovation. In the White Paper on the future of Europe, the European Commission presented several drivers of Europe's future, representing major societal challenges facing Europe's citizens. Ultimately though, only research and innovation can provide sustainable solutions to those challenges. In this sense, the RISE reflections presented here can be considered as sketching out how such investments in Europe's future agenda will crucially have to depend on openness. Open science, open innovation and open to the world: the 3 O's will be essential in addressing both European challenges as well as exploiting new opportunities, no matter what Europe's future cooperation model will be.

This Chapter contains two sections. The first section pursues and concludes the discussion started in the Introduction to this book on the observation that the knowledge-innovation nexus seems to be broken in Europe but also in most of the other developed countries in the world such as the US and Japan. This is reflected amongst others in the debate about the economically invisible productivity impact of research, and in particular the discussion surrounding the impact of publicly funded research. What could be called the 21st Century productivity paradox. As argued here that paradox appears far less a paradox in the case of Europe. On the contrary, the underlying reasons for Europe's innovation deficit appear rather well-known.

166) European Commission, "White paper on the future of Europe. Reflections and scenarios for the EU 27 by 2025", March 2017 (https://ec.europa.eu/commission/sites/beta-political/files/white_paper_on_the_future_of_europe_en.pdf)

5.2 THE 21ST CENTURY PRODUCTIVITY PARADOX

There is, as discussed in the Introduction to this book, growing evidence of a new productivity paradox emerging. That productivity paradox takes different forms. In first instance it takes the form of the old, macro-economic aggregate evidence which points to a general slowdown in productivity growth in some of the richest and most developed OECD countries, such as the US, Japan and Europe[167]. For Europe this trend is actually most pronounced with productivity having today barely recovered from the 2008 financial crisis. Of course, questions can be raised about the underlying structural changes accompanying such declining officially measured productivity growth. Output measurement certainly in sectors such as finance, insurance, health, education, distribution and many other service sectors is open for discussion and measures of labour or total factor productivity are often unlikely to provide clear insights into the growth or decline in the increased efficiency by which such services are being produced or delivered. But the old assumption remains of course that a declining aggregate productivity growth will negatively influence an economy's ability to increase its living standards or fulfil its future commitments whether in terms of future next generations or future sustainability challenges. And certainly for a region such as Europe confronted with ageing, reaping fully the benefits of the knowledge-innovation axis will be essential.

And yet, the breakdown of the knowledge-innovation nexus in the European context appears probably less paradoxical than in the US. As highlighted by Reinhilde Veugelers (2016), one of the RISE expert members: "... typical for Europe is the fact that new firms fail to play a significant role in the innovation dynamics of European industry, especially in the new growth sectors. This is illustrated by their inability to enter, and more importantly, for the most efficient innovative entrants, to grow to world leadership in new sectors. The churning that characterizes the creative destruction process in a knowledge based economy encounters significant obstacles in the EU, suggesting barriers to growth for new innovating firms that ultimately weaken Europe's growth potential." There are several reasons explaining why there are fewer European than US companies growing into world leading innovators discussed in more detail by Veugelers[168] and not addressed here. The greater willingness on the part of US financial markets to fund the growth of new companies in new sectors than in Europe (O'Sullivan, 2008), became also evident from the couple of cases presented in Chapter 4. Financial constraints are, for sure one of the main barriers to innovation for young highly innovative companies.

A second factor underlying Europe's innovation deficit points to the growing gap between the productivity gains achieved by the best, most innovative firms and the rest – an apparent breakdown in the trickling down of innovation towards the other, following firms. Underlying the productivity gap is the observation that particularly in Europe, the high productivity of firms active at the global frontier does not seem to 'trickle-down' to other firms operating predominantly in national and local markets. More broadly, despite the launch of a wide range of policy initiatives and instruments at regional, national and EU level, there seems little noticeable impact on innovation diffusion across firms. In short: it is the failure to diffuse best practices throughout the economy, to let the best firms attract the resources they need to grow which appears to be one of the main structural reasons for Europe's productivity slowdown. It has also resulted in a rising number of low-productivity firms that just "survive". In many, either geographically segmented, or product, or service delivery segmented markets in Europe low-productivity firms operate in a sheer "zombie mode" with not only no replacement or maintenance investments but often also an inability to generate operating income to cover interest expenses on their debt. Such firms not only drag down aggregate productivity, they also trap resources that could be used by more viable and productive firms.

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167) See also European Commission (2016), The economic rationale for R&I funding and its impact, Directorate-General for Research and Innovation, December 2016.

168) See also Veugelers and Cincera (2010)

It is here that a more open, transparent approach is likely to help: accelerating reforms that remove obstacles to competition in particular segments of the services sectors; reforms that maintain and upgrade workers' skills and facilitate their mobility across firms so as to sustain an efficient reallocation enabling the growth of high-productivity firms; challenging some of MS "closed" national higher education systems limiting the mobility of students and staff; supporting lifelong training and removing obstacles to residential mobility across Europe through e.g. lowering transaction costs in housing markets; reforms in financial markets and exit policies such as removing banking sector distortions induced by non-performing loans and reviewing inadequate insolvency regimes, etc.

The failure of trickling-down has of course also implications for growth convergence and social cohesion, a crucial feature of European integration and the formation of the EU. There is today a trend towards an increased concentration of economic activities and innovation in core regions and cities, with less favoured regions lagging increasingly behind. This trend has worsened since the outbreak of the 2008 economic crisis, leaving a persistent gap between central and peripheral regions in the EU in terms of capacity of innovation and economic convergence. Again a more open approach addressing convergence from the perspective of addressing the local knowledge-innovation axis in a more dynamic context paying particular attention to what was called here "related variety", appears essential..

5.3 BROAD POLICY CHALLENGES

Let us now come to some final comments on what could be considered as the core principles of what we like to call here the "RISE doctrine". These will take the form of a number of broad, general policy recommendations, following indirectly from the analysis presented in the previous Chapters.

This new doctrine provides us with three perspectives on openness. Openness as tool addressing the grand societal challenges of our time; with Europe as central player in addressing those challenges with applications at the global level and at the local (city) level, enabling new firms to emerge in newly constructed markets and the scaling-up of existing firms. Second, openness as inclusive tool: as "commons". Openness started here from within the scientific community – the community for whom the production of knowledge is to quote Jean-Claude Guédon (2014) "*the most noble thing human beings can do*" or "*the place where we feel most human*" – with the initiatives on open access and open data, but which became quickly broadened to many other networks and communities building on trust as a precondition to reach higher levels of community thinking and focusing on people as actors of change, rather than institutions. And finally, openness for experimentation, for enabling radical change, for the emergence of, now and then disrupting innovations in new areas, with European and local procurement as open but effective leverage tools using innovation-friendly regulation and a regulatory sandbox providing additional degrees of freedom for testing, for local co-creation, for living labs; for market creation mechanisms to emerge and flourish.

A brief elaboration to conclude:

- The first principle of "openness", the openness as tool addressing the grand societal challenges of our time, should ultimately be seen as our long term guarantee to sustainability, as the conceptual framework for Europe in addressing the SDGs. Such openness positions Europe as it always was: an open knowledge gatekeeper for addressing the societal, global challenges confronting the world as a whole, and Europe in particular. With the high concentration of researchers and research facilities in Europe, the EU owes it to itself and the rest of the world to remain a central player in addressing the big, societal challenges of our times. But here too the knowledge-innovation axis appears more complex than generally assumed and can be said to function poorly today. Traditionally, addressing societal challenges has been a primarily "supply-pushed" concern with the research community playing a central role and becoming even a stakeholder in the way to address such "big challenges", relying in its financial sustainability increasingly on EU-funded research projects addressing those societal challenges. Implementation in terms of innovation has, however, often been disappointing. Typically, users and more broadly the demand side, has been insufficiently involved in the design and development of innovative ways to address those societal, global challenges.

As highlighted in Chapter 3 on Open to the World, whereas there are numerous opportunities for the science community to become the engine of international collaboration in signalling the global challenges ahead and planning ways to overcome them, with a potential significant role for science diplomacy, achieving the SDGs will ultimately depend on success achieved in CO_2 reduction in production, distribution and consumption; in having redirected demand towards more sustainable consumption paths, in developing and designing new circular economy market principles, etc.

In short, it will be crucial to break open the current supply-side research dominance in addressing societal challenges, which has sometimes cornered the discussion and debates to technical debates about measurement, evidence and methodologies. The appendices provide two best practice examples on how the inter-linkages between the 3 O's will be an essential aspect for reconnecting the research-innovation nexus.

- The second notion of openness addresses individual or group exclusion. Openness should be viewed here as inclusive tool: openness as "commons". Again, the debate on such "inclusive openness" started from within the scientific community with the debates on open access, open data, citizen science and the necessity of the academic community to adhere to strict rules of scientific integrity to keep the trust it had historically built up as discussed and reviewed in Chapter 2 on Open Science. But it includes today also the inclusive openness with respect to global networks and local communities' way in which knowledge is being absorbed, developed, refined through which new high value added is being created. And it includes today, as Chapter 4 highlights, much more people: innovators, as actors of change. Such openness as inclusion tool, as commons depends essentially on trust.

- The third meaning of openness is in relation to experimentation. It is of course the livelihood of science and research, but here too openness for experimentation, for innovation deals, for green deals, for testing, for local co-creation, in experimental areas in cities; for market creation combining new sorts of opportunities for exchanging and extraction value, is part of such openness. Openness in a certain sense as regulatory tool. For an old continent such as Europe, with its complex institutional set-up with old European treaties fixing more or less in cement the governance modes of EU and MS policy prerogatives, this is of course a formidable, if not the most formidable challenge. It is, however, a central factor behind the broken European knowledge-innovation axis. Tackling it will require in a certain way similar creativity, research and innovation thrive on. But here too once one is prepared to go into the detail of policy opportunities; there appear numerous opportunities for reigniting the knowledge innovation axis. As discussed in Chapter 1, policy measures to harness public procurement in support of innovation such as the Lead Market Initiative can be scaled-up with measures incentivising private procurers to be more demanding in terms of requesting innovative solutions. Such scaling up can take place at local city level, involving city-labs and various other regulatory-sandbox experimental zones. The EU has plenty of internal borders which could become ideal experimental zones for such openness to experimentation.

The central question addressed in this RISE book was whether the 3 O's paradigm shift in research and innovation, as proposed by Commissioner Moedas, was likely to bring about new dynamics to Europe's "broken" knowledge-innovation nexus. Our answer is yes, but only if it is fully embedded within a new policy vision. A vision which sets out a European long-term framework: a new social contract, allowing for flexibility, learning and experimentation whereby openness in research and innovation and openness to the world is part of the new digital democratization process bringing together citizens, academics, researchers, innovative firms building a common project "to the benefit of all". A vision which stands for values which might have come under pressure in other parts of the world but which remain for Europe core values: values not open for debate.

Appendices

TABLE OF CONTENTS

Appendix 1 165

A key input to the work of the RISE OS group was the two-day workshop "Open Science: a framework for accessibility, transparency and integrity of scientific research", held in Palma, Mallorca. This brought together the RISE OS group and 12 invited external specialists. The outcomes of the Mallorca workshop have been brought together in a formal declaration – the Mallorca Declaration – which has been endorsed by all workshop participants.

Appendix 2 & 3....167

Two case studies focusing on inter-linkages between the 3 O's

Some members of the OS group undertook additional individual work separate from that of the OS group and focusing on the interlinkages between the 3 O's rather than OS per se. This work is presented in two case studies.

The first, '**Funding Mechanisms: A Case Study on Translational Oncology in the World of Open Science, Open Innovation and Open to the World**', authored by Julio E. Celis and Dainius Pavalkis, provides a stimulating example of how to build research ecosystems where the 3 strategic priorities established by Commissioner Carlos Moedas could develop and progress in accord to tackle a major societal challenge.

The second, "**Climate-KIC: A Model for Open Innovation that is Open to the World**", authored by Mary Ritter presents a cross-sectoral European Knowledge Innovation Community (KIC) model of open innovation which builds on the output from open science and provides a platform for global collaboration. An integrated innovation framework takes scientific output through to application, commercialisation and the market, leading to societal and economic impact – supporting the 3 O's vision for Europe.

THE MALLORCA DECLARATION ON OPEN SCIENCE

Preamble: Open Science is essential if the world is to successfully address the major challenges that it now faces. To have impact, Open Science must be based on accessibility, transparency and integrity, enabling trusted collaboration for research excellence and optimal delivery. This declaration specifically addresses the key barriers to Open Science, and builds on previous statements concerning Open Science[169].

ACHIEVING OPEN SCIENCE

1. Remove the barriers that extreme competition for limited resources create for Open Science

True progress on Open Science will require fundamental rethinking of how research is funded and researchers are rewarded. Policies to promote Open Science should include incentives and not just mandates.

Open Science does not thrive on extreme competition. To ensure, therefore, that Open Science practice does not jeopardise careers it is essential to bring funding success rates back to a position where Europe's best researchers can reasonably expect to attract and maintain funding for their best work. Due to the proven difficulty in predicting productivity, it is also critical to support as many highly qualified, early-career researchers as possible. Accordingly, the allocation of funds should be adjusted so that all applications that meet key evaluation quality criteria should receive appropriate funding.

For career assessment and advancement, and for evaluation generally, metrics such as numbers of publications and journal impact factors should not substitute for the meaningful assessment of an individual's work. Assessment criteria should also explicitly and directly reward reagent and protocol sharing, data sharing, and open resource development.

2. Implement Open Access publishing where publication is part of the continuum of research

Monopolisation and cartelisation of the publication enterprise are not compatible with Open Science. New funding and business models need to be developed to establish a sustainable and affordable Open Access publishing system. The success of Open Science will depend on Open Access publishing having sufficient resources to implement a fair and transparent evaluation process and to ensure the quality, reproducibility and integrity of published research. Posting on recognized pre-print servers, data publishing platforms and self-archiving on shared platforms ('Green Open Access') provide useful complementary solutions for immediate pre-publication sharing of Open Science research.

169) http://ec.europa.eu/research/science-society/document_library/pdf_06/recommendation-access-and-preservation-scientific-information_en.pdf; http://recodeproject.eu/; http://www.budapestopenaccessinitiative.org/; http://bookshop.europa.eu/en/open-innovation-open-science-open-to-the-world-pbKI0416263/

3. **Establish competence and confidence in the practice of Open Data**

Competence in data management and data sharing, establishing a holistic interoperable infrastructure and creating a supporting culture for openness are three core challenges for the practice of Open Data. These should be supported by the development of training programmes designed to adopt best practice for data management skills; promote an increased awareness of the many existing data repository options; and support ways to measure and reward data reuse, e.g. encouraging direct citation of data, educating grant award committees about assessment, and creating funding for explicit career tracks for data and software specialists.

4. Ensure research integrity

Research integrity and the responsible conduct of research are fundamental to ensuring that research findings are reliable, reproducible and trustworthy. Best practice in the conduct of research is, therefore, essential to the success of European science. A common European research integrity code compatible with international declarations such as the Singapore and Montréal statements should underlie all European research, and key stakeholders should be identified to work together to build an ecosystem that ensures research integrity. To support this, the culture of research integrity should be nurtured through education and training programmes specifically tailored for both early and more senior researchers. This is essential if Open Science is to flourish and earn the trust of the research community and wider society and to avoid the waste of scarce resources.

5. A cohesive European approach

European Institutions, Member States, universities, research centres, and researchers should support the fulfilment of the principles embodied in this Declaration and in the further development of relevant international laws and policies.

Realigning funding, publishing, and data sharing with the goal of Open Science practice will promote a global shift towards a scientific culture that will enhance the acceleration of discovery and innovation worldwide.

Context: For Europe, Open Science is essential to fully achieve its target knowledge- and innovation-based economy. The Research, Innovation, and Science Policy Experts (RISE) Open Science High Level Group gives direct strategic support to Carlos Moedas, the European Commissioner for Research, Science and Innovation, and to the European Commission. To interrogate key issues concerning Open Science, the RISE group came together with 12 invited external specialists at The University of Balearic Islands, 24th-25th May 2016. Work focussed on how to create a culture for Open Science and Research Integrity by removing barriers and promoting incentives in research funding, career advancement and publishing. Key outcomes are brought together in this declaration. It is not a regulatory document and does not represent the official policies of the countries and organisations that participated in the workshops.

APPENDIX 2 CASE STUDY:

Funding Mechanisms: A Case Study on Translational Oncology in the ERA of Open Innovation, Open Science, and Open to the World[170]

Julio E. Celis and Dainius Pavalkis

1. INTRODUCTION

To invigorate the European Research Area (ERA), the Commissioner for Research, Science and Innovation, Carlos Moedas, in 2015 established three strategic priorities: Open Innovation (OI), Open Science (OS), and Open to the World (OW). Given that these priorities are interlinked, the RISE OS Group deemed that in addition to addressing main concerns independently, it was important to single out case studies of specific disciplines/research environments where the 3 O's could develop in accord to address major societal challenges.

Towards this aim, the policy brief deals with translational cancer research[171] in the age of personalized medicine[172] that promises to "tailor the right therapeutic strategies to the right patient at the right time" and make cancer treatment more cost-effective. It briefly describes the efforts made by the cancer community and policy makers for the last 14 years to structure translational research, and that have led to the establishment of Cancer Core Europe, a virtual consortium of six leading European cancer centres – a legal structure – with the critical mass of expertise, resources, patients, shared data, and state-of-the-art infrastructures needed to generate stimulating and innovative environments where the 3 O's could develop and flourish. Working beyond borders to unite innovative centres of excellence – a beginning for global collaboration in a multi-stakeholder setting – is Cancer Core Europe's vision for effectively translating research progress to the clinic, both for the benefit of patients and society as a whole.

Presently, numerous barriers slow down the translational process across the cancer research continuum, and among them, the lack of suitable funding instruments to sustain translational research and boost academic-driven innovations is at the heart of the problem, particularly considering the escalating costs of cancer care and the demands related to the increasing size of the elderly populations. Based on an online consultation with the cancer community as well as numerous individual and group discussions, this section provides recommendations concerning modifications to funding mechanisms and actions that might be necessary to accelerate the translational process (bench to bedside and back to bench[173]). It is clear that the European Commission cannot do everything, functioning mainly as a catalyst, but better coordination of the EC's and the Member States' research agendas and policies would be necessary to enhance coherence and provide continuity to transnational actions that are required to tackle the burden posed by cancer. Even though the case study centres on oncology, the principles and suggestions apply to all chronic diseases.

[170]) This case study is written by Julio E. Celis and Dainius Pavalkis, Members of the RISE Open Science Group

[171]) Although several definitions currently exist for translational research, only a minority cover the complete cancer research continuum from bench to bedside and vice versa. One of these states: "Translational research uses knowledge of human biology to develop and test the feasibility of cancer-relevant interventions in humans OR determines the biological basis for observations made in individuals with cancer or in populations at risk for cancer. The term "interventions" is used in its broadest sense to include molecular assays, imaging techniques, drugs, biological agents, and/or other methodologies applicable to the prevention, early detection,, diagnosis, prognosis, and or treatment of cancer". (National Institutes of Health, 2014)

[172]) Personalized medicine is a medical model that separates patients into different groups – with medical decisions, practices, interventions and/or products being tailored to the individual patient based on their predicted response or risk of disease. The terms personalized medicine; precision medicine, stratified medicine and P4 medicine are used interchangeably to describe this concept though some authors and organizations use these expressions separately to indicate particular nuances (Wikipedia).

[173]) Bench to bedside and back to the bench defines a process that translate basic research discoveries into clinical applications, and that brings back clinical problems to basic/preclinical research.

2. CANCER: A GROWING PROBLEM AND A MAJOR SOCIETAL CHALLENGE

Cancer is a major health issue affecting our society, and the situation is set to deteriorate globally as the population ages. The number of new cancer patients in Europe alone will increase during the next two decades, from 3.6 to 4.3 million, amounting to 716,000 additional cases each year (Steward and Wild, 2014). Furthermore, the number of patients living with a cancer diagnosis is increasing even further due to improved early detection and more efficient treatments, making cancer a major chronic disease. The magnitude of the problem places a considerable extra burden on the health care systems due to multiple lines of treatment, diagnostic procedures, and prolonged follow-up both of the disease and the treatment-related complications to provide meaningful cancer survivorship. Health expenditure on cancer in the EU increased continuously from €52.7 billion (in 2014 prices) in 1995 to €87.9 billion in 2014. Cancer drugs accounted for a growing share of the total health expenditure with a rise from 12 percent in 2005 to 23 percent in 2014 (Jonsson, et Al., 2016).

Today, basic research prompted by the explosion of novel high-throughput technologies available for the analysis of genes/gene mutations and their products is leading to a better understanding of the biological processes underlying cancer; yet advances that improve lives, extend survival, and enhance the quality of life of cancer patients happen only rarely. The latter is partly because the pathways by which fundamental discoveries translate into new diagnostic tools and more efficient tailored treatments are complicated, lengthy, and difficult to organize, and as a result, translational research is slow, inefficient, and expensive. Overall, Europe, as well as the rest of the world, is not entirely prepared to take full advantage of the continuously generated knowledge as it does not have a long-term shared research strategy to ensure that basic science discoveries reach the patients and lacks essential translational infrastructures linking research with innovation.

Discovery-driven translational cancer research in the age of personalized medicine has the patient at the centre and addresses the research continuum from basic to clinical and outcome research before adoption by the healthcare systems (Mendelsohn et Al., 2012; Khoury, et Al, 2007). It requires multi-disciplinarity, i.e. collaboration between researchers and clinicians from various disciplines (surgery, radiotherapy, medical oncology, molecular/immune pathology, imaging, and epidemiology), patients, industry, regulatory bodies, funders, novel high-end "Omics" technologies (next-generation genome sequencing, proteomics, epigenomics, metabolomics) as well as an in-depth understanding of the functioning of the immune system. Also, early clinical trials structures are needed moving towards next generation trials, with registries containing clinical information, standardized clinical protocols, bio-repositories, platforms for molecular diagnostics and imaging. Moreover, it demands a significant number of patients, high-quality research and clinical validation, as well as data openness and sharing; all of which must be coordinated, of sufficiently large-scale to allow studies with statistical power, and receptive to the needs of society as a whole.

The breadth and scope of this challenge have called for a change in the cultural attitude towards cancer research in Europe. A move from regional/national efforts into continent-wide collaborations and a concerted action, involving all stakeholders is deemed critical for accelerating the pathway from laboratory discoveries towards treatments and diagnostics that benefit patients. In particular, international efforts supported by collaborative networks amongst Comprehensive Cancer Centres (CCCs) – institutions where treatment and prevention integrate with research and education – and basic/preclinical research centres across Europe are essential to cover the whole cancer research continuum and for providing inspiring environments in which the 3 O's[174] can thrive. Achieving these objectives will require a pro-active and sustained effort from all the stakeholders as well as a great deal of political creativeness and commitment at all levels of the EU institutional triangle of power.

3. STRUCTURING TRANSLATIONAL CANCER RESEARCH: FROM THE START OF THE EUROPEAN CANCER RESEARCH AREA TO THE LAUNCH OF CANCER CORE EUROPE

In September 2002, the EU Commissioner for Research Phillip Busquin promoted the creation of the European Cancer Research Area (ECRA) at a conference "Towards

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[174]) *http://europa.eu/rapid/press-release_SPEECH-15-5243_de.htm*

greater coherence in European Cancer Research" jointly organized by the European Parliament (EP) and the European Commission (EC). European cancer research was fragmented and "was not delivering the outcomes expected by healthcare professionals and citizens; there was a need to create a common European strategy for cancer research"[175] (Celis and Ringborg, 2014).

A broad range of stakeholders participated in the meeting, all of which agreed that better coordination of cancer research throughout the cancer research continuum was vital to decrease the disease problem. In his concluding remarks, Commissioner Phillip Busquin stated, "ECRA will be what you make of it", a simple, but strong message meant to encourage the various stakeholders to join forces tackling the disease in partnership. Cancer was a priority in the sixth Framework Program (FP) thanks to the support of the European Parliament, and for the first time a FP could explicitly support clinical research in order to take advantage of genomic research and novel technologies (Van de Loo et Al., 2012; Celis and Ringborg, 2014); thus, the opportunity was there to change the course of action.

Encouraged by the outcome of the Conference as well as by further discussions with the cancer community (Saul, 2008; Celis and Ringborg, 2014) and the EP, the Commissioner in 2004 established a temporary "Working Group on the Coordination of Cancer Research in Europe" expected to advise the Commission and make recommendations on the subject. The group chaired by MEP M. Vim van Velzen and composed of representatives from clinicians, basic researchers, health authorities, funders, patient organizations, and industry, was asked to identify barriers to collaboration as well as to find ways to promote the development of partnerships among the Member States.

As a result of the Working Group recommendations, the Commission in 2004 launched a call for proposals in FP6 leading to the funding of the Eurocan+Plus project in 2006 within the framework of the specific programme entitled 'Integration and Strengthening of the European Research Area' in the domain Life Sciences, Genomics and Biotechnology for Health. The broad and inclusive consortium was expected to deal with coordination issues and was asked to determine how improved coordination could be implemented using existing support schemes such as ERA-NETs and Article 169 of the Treaty establishing the European Community (TEC)[176], now Article 185 of the Treaty on the Functioning of the European Union (TFEU)[177]. The Eurocan+Plus Project has been one of the largest ever consultation of researchers, cancer centres, healthcare professionals, funding agencies, industry, and patients' organizations in Europe.

The Eurocan+Plus project stressed the need to improve collaboration between basic/preclinical research and CCCs and proposed establishing a platform for translational cancer research composed of interconnected cancer centres with collective projects to accelerate rapid advances in knowledge and their translation into better cancer care and prevention. It was regarded as a precursor, in the long-term, of a virtual European Cancer initiative[178] (Celis and Ringborg, 2014). The project also proposed the setting up of an ERA-NET to support translational cancer research. The ERA-NET on Translational Cancer Research (TRANSCAN) was funded under FP7 and brings together ministries, funding agencies, and research councils having programs on translational cancer research.[179]

In 2008, FP6 had ended, and since FP7 had already started in 2007, a gap was left to be dealt with if the Platform proposal was to become a reality. Towards this end, the directors of 16 leading European cancer centres met in Stockholm in 2008 to define the Platform concept and to discuss steps towards its implementation. To mark their commitment, they signed the "Stockholm Declaration", openly stating their intention to join forces and share resources (Ringborg, 2008). The declaration signalled a paradigm shift that was catalysed by the leadership, commitment, trust, and shared vision of basic and clinical researchers; leading by example!

175) http://ec.europa.eu/research/info/conferences/cancer/cancconf_prog.pdf

176) http://www.eurosfaire.prd.fr/7pc/doc/1253547916_06_wolfgang_wittketoolbox.pdf

177) http://ec.europa.eu/research/era/what-is-art-185_en.html

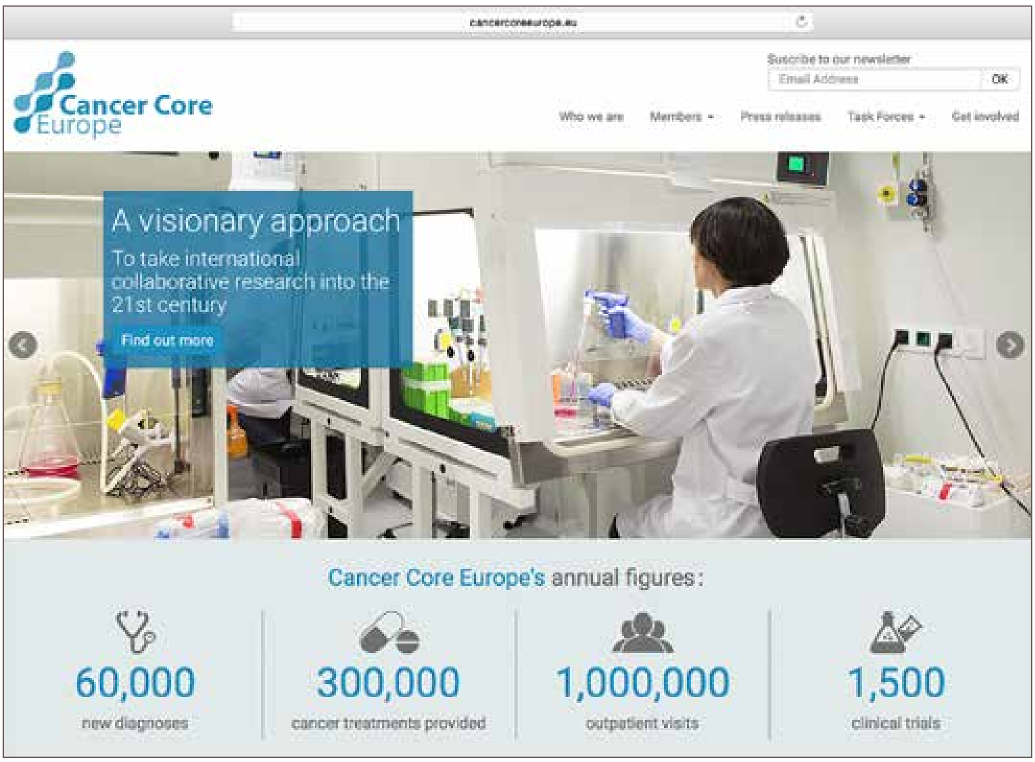
178) http://ecancer.org/journal/2/full/84-eurocan-plus-report-feasibility-study-for-coordination-of-national-cancer-research-activities.php

179) http://www.transcanfp7.eu/pages/transcan-objectives.html

Several preparatory meetings took place in 2008 to organize the activities of the Stockholm group and the first steps towards moving the "Stockholm Declaration" into reality were discussed with the principal stakeholders at a meeting that took place at the UNESCO headquarters at the end of 2008 "Turning the Stockholm Declaration into Reality: Creating a World-class Infrastructure for Cancer Research in Europe" (Brown, 2009). At this meeting, it became apparent that to move the proposal forward, the scientific community had to involve cancer organizations and science policy advisers to nurture and accelerate the process. The European Cancer Organisation (ECCO)[180], a multidisciplinary organization embracing 60,000 plus oncology professionals working across the cancer continuum, was the obvious partner as they had just created several policy platforms such as the Oncopolicy Committee with policy advisors (Jose Mariano Gago, former Portuguese Minister of Research, Science and Technology, Federico Mayor, former Director-General of UNESCO, Phillip Busquin, former Commissioner for Science and Technology, Peter Lange, former Director General of Health and Life Sciences, German Federal Ministry of Education and Research, and Frank Gannon, former Director of the European Molecular Biology Organization), the European Academy of Cancer Sciences (EACS), and the Oncopolicy Forum (Celis and Gago, 2014).

As a consequence of the Eurocan+Plus project recommendations and backing from the cancer community and science policy advisors, the EurocanPlatform Network of Excellence, led by Ulrik Ringborg from the Karolinska Institutet, was funded through FP7 in 2011, nine years after the critical 2002 Conference.[181] The mission of the EurocanPlatform, which brought together 23 European cancer research centres and 5 cancer organizations, was to create a translational cancer research consortium aimed at pro-

Figure A.1: Cancer Core Europe: Paving the way to a multi-site cancer institute



Source: with the permission of Fabien Calvo

[180]) *http://www.ecco-org.eu/*

[181]) *http://www.ecco-org.eu/*

moting innovation in prevention, early detection, and therapeutics. The primary objectives have been to support the development of personalized cancer medicine based on the understanding of the biology underlying the disease(s), to stratify patients for treatment, and to identify high-risk individuals for prevention and early detection. So far, variable geometries have been established for collaborations within the areas of prevention, early detection, therapeutics, and outcomes research.

A main achievement of the EurocanPlatform Consortium was the creation of Cancer Core Europe in 2014 (Celis and Ringborg, 2014; Eggermont et Al., 2014), a virtual patient-centred multidisciplinary shared infrastructure addressing the cancer care/research continuum in partnership among six leading EurocanPlatform cancer centres:

- Gustave Roussy Cancer Campus Grand Paris,
- Cambridge Cancer Center, Cambridge,
- The Netherlands Cancer Institute (NKI), Amsterdam,
- Karolinska Institutet (KI), Stockholm,
- The Vall d'Hebron Institute of Oncology (VHIO), Barcelona, and
- The German Cancer Center with its CCC the National Centre for Tumour Diseases (DKFZ-NCT), Heidelberg).

A. Eggermont and O. Wiestler championed the creation of Cancer Core Europe utilizing a bottom-up approach, and in the spirit of the "Stockholm Declaration", each of the centres allocated their own resources to incite cross-border collaboration.

Cancer Core Europe is a transformative initiative, a virtual "e-hospital" that will provide a framework where basic and translational research occur alongside clinical research to promote innovation[182] (Fig. A.1). This paradigm will allow patients to benefit directly from experimental findings, and observations made in the clinic will, on the other hand, inform research performed at the virtual centre; fostering a patient-centred approach because of improved clinical effectiveness.

Cancer Core Europe has a significant critical mass; per year it sees 60,000 newly diagnosed patients, treats about 300,000 patients, has about 1,200,000 consultations, and around 1,500 clinical trials are being conducted at the six centres. The virtual centre will provide "powerful translational platforms, inter-compatible clinical molecular profiling laboratories with a robust underlying computational biology pipeline, standardized functional and molecular imaging, as well as commonly agreed Standard Operating Procedures (SOPs)"[183]. By generating and sharing relevant quality assured clinical and "Omics" big data as well as providing a single stop shop for the industry to collaborate via public-private partnerships, Cancer Core Europe is expected to speed up the development of personalized cancer medicine by creating stimulating environments where the 3 O's, and in particular science diplomacy, could develop and flourish. Delivering innovations for patients across the whole translational research continuum will require, however, clinical validation, an important step that is missing today.

Sharing data across all centres is crucial, and with funding from the European Institute of Innovation & Technology (EIT) Health project, the data sharing Task Force of Cancer Core Europe "is already supporting the construction of a data sharing platform, in which patient advocates, as well as ethical, regulatory and legal experts, will be an integral part of the process to address patient and data privacy issues". Collective efforts to pool information "will transform clinicians' and researchers' perception of cancer, thereby permitting a deeper understanding than any single centre could achieve on its own". Moreover, the prospectively created, fully clinical and research annotated databases will provide a high quality and reliable foundation, supporting outcome research projects within oncology, which until now have been missing. The latter is central as clinical effectiveness data is needed to assess cost-effectiveness, and the healthcare systems need this information to prioritize between different evidence-based treatments and diagnostics. "Going beyond borders to unite innovative centres of excellence, a beginning for global collaboration is Cancer Core Europe's vision for effectively translating research progress to the clinic".

Cancer Core Europe encourages knowledge sharing, improved flow of information, as well as dissemination to society as a whole, and by being a legal structure is

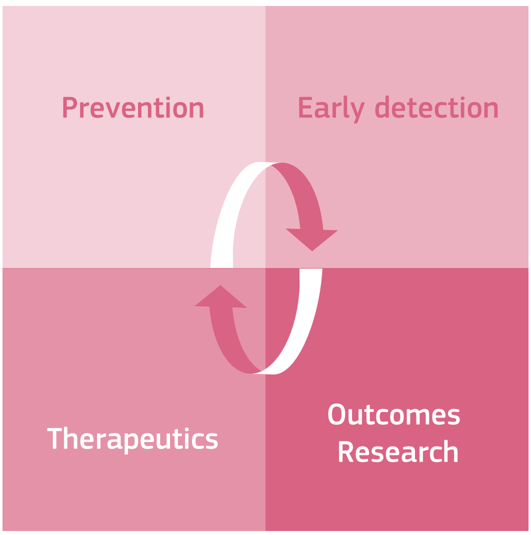
[182]) *http://www.cancercoreeurope.eu/index.php*

[183]) *http://www.cancercoreeurope.eu/index.php*

in a unique position to optimize the transition to OS. In the long-term, the aim of the consortium is the creation of a sustainable "virtual multi-site European Cancer Institute (ECI), which will drive the development of new treatments and earlier diagnoses for patients, and more efficient cancer prevention for Europe's citizens" (Celis and Ringborg, 2014; Eggermont et Al., 2014). "The creation of such ECI may pave the way towards the establishment of a European Institute(s) for Health Research, similar to the National Institute of Health (NIH) in the USA" (Celis and Ringborg, 2014).

In the future, other centres are expected to join Cancer Core Europe to expand the collaboration; however, inclusion will be based on the capacity to provide scientific excellence. Towards this end, the EurocanPlatform consortium in cooperation with the EACS has developed quality criteria and methodology for designation of CCCs of Excellence (Rajan et Al., 2016). Efforts must be made, however, to ensure that all countries in Europe benefit from this development. It should be noted that the European Organization of Cancer Institute's (OECI) has a focus on the development of quality controlled clinical cancer centres and cancer units in Europe[183], and several members from Central and Eastern Europe are already part of the OECI and are working in this direction, including training of researchers.

Figure A.2: Integrating therapeutics with other geometries



Source: Autors

In the future, a similar initiative to Cancer Core Europe is expected within the area of prevention[184] led by Christopher Wild from the International Agency for Research on Cancer (IARC), and supported by ongoing structuring efforts in early detection and outcomes research. By establishing close links amongst these initiatives, it will be possible to cover the whole cancer research continuum in partnership (Fig. A.2).

Currently, there are several other relevant initiatives in Europe aimed at accelerating the translation of research into the clinic. For example, Cancer Research UK (CRUK)[185] funds a network of centres engaged in translating discoveries into novel therapeutics and diagnostics. The German Cancer Consortium, linking eight CCCs, is a national platform for translational cancer research aiming at personalized cancer medicine.[186] Likewise, INCa in France has developed a network for translational research in selected cancer centres (SIRIC)[187]; the underlying concept being that effective partnerships are essential to maximize the impact of research. Additional examples, to name a few, include the Francis Crick Institute that aims at becoming one of the largest centres for translational biomedical research in Europe[188], as well as clinical infrastructures such as the European Advanced Research Infrastructure in Medicine (EATRIS)[189], the European Clinical Research

183) http://www.oeci.eu/

184) http://eurocanplatform.eu/news/8267-european-cancer-centres-finally-united-in-long-term-collaborative-partnerships.php

185) http://eurocanplatform.eu/news/8267-european-cancer-centres-finally-united-in-long-term-collaborative-partnerships.php

186) http://www.dkfz.de/en/dktk/

187) http://www.e-cancer.fr/Professionnels-de-la-recherche/Recherche-translationnelle/Les-SIRIC

188) https://www.crick.ac.uk/

189) http://www.eatris.eu/

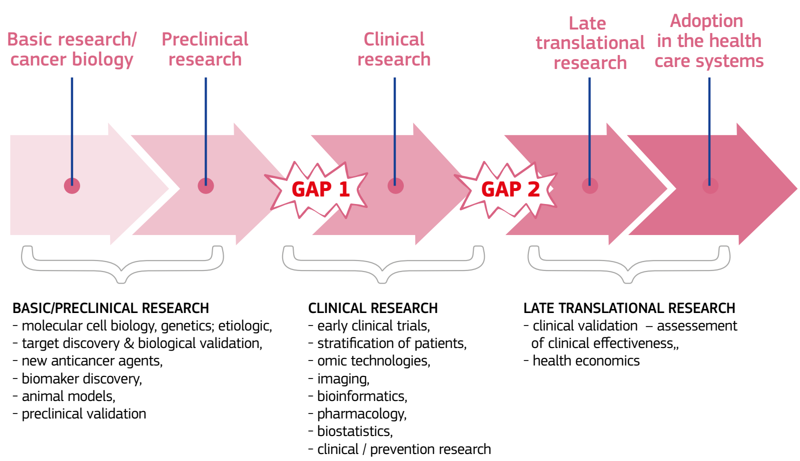
Infrastructure Network (ECRIN)[190], and the Biobanking and Biomolecular Resources Research Infrastructure (BBMRI-ERIC)[191].

In the USA, the National Centre for Advancing Translational Sciences was created in 2002 by the NIH to improve the translational research process so that new therapeutics reaches the patients quicker.[192] And recently, President Obama proposed the creation of a "Cancer Moonshot" initiative to cure cancer in partnership,[193] very much along the lines of the European efforts. In a round-table discussion, Vice-President Joe Biden stated, "I believe we can make much faster progress – as an outsider looking in from a different perspective – if we see greater collaboration, greater sharing of information, breaking down some of the research that is trapped inside of silos".[194] The "Cancer Moonshot" initiative is indeed complementary to the European Cancer Core program, and close cooperation between these efforts may prove instrumental for tackling a significant societal challenge such as cancer worldwide. Cancer Core Europe has sent an official letter to Vice President Biden informing him about the latest developments, and in connection with his visit to Stockholm in August this year, the American Embassy in Stockholm initiated contacts between his administration of the "Cancer Moonshot" initiative and Cancer Core Europe.

4. BARRIERS TO TRANSLATIONAL CANCER RESEARCH IN THE ERA OF PERSONALIZED MEDICINE

With the advent of personalized medicine, which promises to "tailor the right therapeutic strategies to the right patient at the right time" and make cancer treatment more cost-effective (Mendelshon et Al., 2012), we are confronted with exciting opportunities as well as many hurdles that slow down the implementation of significant advances in fundamental research into clinical practice.

Figure A.3: Translational Cancer Research – A coherent research continuum. Kindly provided by U. Ringborg, Karolinska Institutet



Source: with the permission of Ulrik Ringborg

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190) *http://www.ecrin.org/*

191) *http://bbmri-eric.eu/*

192) *https://ncats.nih.gov/*

193) *http://www.nature.com/news/obama-proposes-cancer-moonshot-in-state-of-the-union-address-1.19155*

194) *https://today.duke.edu/2016/02/bidenvisit*

Within the oncology area, the primary aim of translational research is to accelerate the conversion of basic scientific knowledge to benefits for patients, by ensuring access to a full range of existing treatment options such as surgery, radiotherapy, and drugs. The outcome of science and technology-driven innovations can be therapeutic drugs, diagnostic tools, and medical devices, but in all cases, findings need to be validated in the clinical setting if the ultimate goal is innovation for the patient.

Given that cancer is not a single disease, but many diseases with a significant number of subgroups within each of the tumor types (Venkatesan and Swanton, 2016), it is becoming clear that soon every patient should be treated individually based on his/her molecular make-up and genetic determinants, thus moving away from the old one-size-fits-all model. How new therapies are discovered and developed, however, is not a straightforward process by far, as the translational cancer research continuum is complicated and lengthy, comprising many phases, teams, stakeholders, and infrastructures (Fig. A.3)[195]. Presently, this process functions in silos since it has proven difficult to bridge the gaps between basic/preclinical and clinical research (Gap 1, Fig. A.3), as well as between clinical research and adoption of innovations in the healthcare system (Gap 2, Fig. A.3). Moreover, competition between research centres and research groups may be an obstacle when applying OS.

Today, the molecular heterogeneity of tumours poses a major hurdle to molecularly-driven early clinical trials using stratified patient groups and, as a result, new clinical trials methodology is emerging in which next generation clinical trials are combined with next generation diagnostics to stratify patients and predict treatment outcome (Mendelsohn et Al., 2015). For utility for patients, the clinical efficacy of new diagnostic and treatment technologies from clinical trials has to be assessed for clinical effectiveness (clinically validated) in unselected patient populations, with both cancer survival and quality of life being the most significant endpoints. Integration with health economics makes cost-effectiveness analyses possible, and a medical product is then in place. Since cancer treatment is usually multimodal, the combination with surgery, medical oncology, and radiation therapy will be the next steps. Here, traditional clinical trials are conducted by existing national and international networks. The mission of research is to provide evidence for innovative diagnostic and treatment technologies, while that of the health care system is to establish quality assured evidence-based medicine with follow-up of outcomes.

Currently, numerous barriers deter the translational process across the continuum, and some are listed in Table A.1. These obstacles must be overcome to ensure that fundamental discoveries translate into interventions, and the availability of appropriate funding mechanisms that stimulate academic-driven innovations is in particular vital to invigorate the process. Capitalizing on research is crucial, as there is no application without discovery, and Horizon 2020, the financial instrument implementing the Innovation Union, has pledged to use research as a tool to promote innovation to generate economic growth and well-being.[196]

5. CURRENT FUNDING MECHANISMS ARE NOT ADEQUATE TO SUSTAIN TRANSLATIONAL RESEARCH AND BOOST SCIENCE-DRIVEN INNOVATIONS

As stated above, translational cancer research in the age of personalized medicine has the patient at the centre and uses research as a tool to develop new diagnostic technologies, treatments, as well as prevention strategies. It employs a multidisciplinary team approach and demands international collaboration to achieve the critical mass of expertise, resources, patients, and state-of-the-art infrastructures that are required to take discoveries effectively into clinical practice. Furthermore, it needs funding mechanisms that take into account (i) the complexity of science-driven innovations, the length of the translational cancer research continuum as well as the requirements of OI and OS, (ii) the aspirations of early-career investigators, and (iii) the need for supporting research infrastructures (RIs).

[195]) *http://deainfo.nci.nih.gov/advisory/pcp/archive/pcp04-05rpt/ReportTrans.pdf*

[196]) *http://www.eua.be/Libraries/funding-forum/EUA_andersen_article_web.pdf?sfvrsn=0*

Since the establishment of ERA in the year 2000[197], the EU FPs have funded transnational cooperation (collaborative projects, networks of excellence) between the EU Member States and other countries, and coordination activities like the ERA-NET scheme and Article 185 (TFEU) actions have been introduced to improve cross-border research cooperation. Lately, Joint Programming, a Member State-led initiative, was implemented to address grand challenges by strengthening coordination of EU and Member States R&D efforts[198]. Furthermore, the Innovative Medicines Initiative (IMI),[199] a public-private partnership scheme, was launched to accelerate the development of more secure and efficient medicines.

Indeed, the above funding mechanisms have proven valuable for supporting transnational research collaboration aimed at addressing some of the ERA goals.[200] However, to confront a major challenge like personalized cancer medicine, a revision of some of these instruments is necessary to provide the sustainability required to keep multidisciplinary transnational collaborations for prolonged periods of time, one of the key factors for stimulating science-driven innovations in oncology.

Currently, there are very few funding instruments that meet the aspirations of early-career investigators (scientist, clinicians) wishing to embark on translational oncology. The journey is long and uncertain; there are cultural differences between scientists and clinicians, and there is a lack of enticements and rewards to engage them. The ERC[201] which supports excellence in basic research has been instrumental in supporting independent young investigators and something similar is needed for translational cancer research.

197) http://www.consilium.europa.eu/ueDocs/cms_Data/docs/pressData/en/ec/00100-r1.en0.htm

198) http://ec.europa.eu/research/era/art-185-in-horizon-2020_en.html

199) https://www.imi.europa.eu/

200) https://ec.europa.eu/research/evaluations/pdf/archive/other_reports_studies_and_documents/fp7_interim_evaluation_expert_group_report.pdf

201) https://erc.europa.eu/

As far as RIs are concerned, Members States have committed to pan-European RIs through the European Strategy Forum on Research Infrastructures (ESFRI) Roadmap. However, the long-term sustainability of RIs remains as the prime obstacle, and this will necessitate further financial commitment from the Member States.[202]

6. RECOMMENDATIONS

Based on an online consultation with the cancer community[203] as well as numerous individual and group discussions, some significant concerns ar identified in need of consideration when formulating the recommendations. These included (i) the lack of sustainability to keep up collaborations and the few opportunities for bottom-up initiatives, (ii) the dearth of incentives for early-career scientists and clinicians to participate, (iii) the requirement for sustainable infrastructures, and (iv) the need for better coherence between the Member States and EC research programs and policies.

We would like to emphasize that coordination and sustainability issues have already been discussed with Member State funders in the European Partnership for Action Against Cancer (EPAAC) Joint Action (Celis et Al., 2013). In the deliberations, it became increasingly clear that further work was required to overcome the shortcomings. Along the same lines, the EurocanPlatform project has considered strategies to develop sustainability, OI, and OS throughout the stages leading to the creation of Cancer Core Europe.

202) http://www.rich2020.eu/sites/all/themes/rich/files/1.%20Octavi%20Quintana.pdf

203) The questionnaire was s1ent to the EACR, the EACs and a number of cancer centres. In all, we received 210 responses. Some of the questions posed in the consultation included (i) why are the current funding mechanisms not adequate to translate research findings to patients, (ii) how should EU funding mechanisms best support translational research in the era of personalised medicine, (iii) how to convince the Member States to increase coordination and put additional money, (iv) how do we achieve better coherence between national and EU programmes, (v) should the ERC fund extensive international translational research, (vi) should the ERC stimulate researchers at all stages of their career to engage in translational research, (vii) what particular type of alternative/modified funding instruments would you like to see implemented, (viii) do you support Open Access Publishing, (ix) do you support access and sharing of data and metadata, (x) what infrastructures are needed particularly in the era of personalised medicine and OS, (xi) should the cancer community provide evidence-based advice to policymakers, and (xii) how can the cancer community engage civic society.

Below, some suggestions are provided concerning modifications to existing funding instruments as well as actions that might be required to boost the translation of research discoveries for the benefits of patients (bench to bedside and back to bench).

A. Adjust existing funding mechanisms to enhance translational cancer research.

Collaborative research schemes and fundamental research

- Collaborative research schemes: The FPs schemes fund the formation of large cross-border collaborative consortia to address significant challenges, cancer included. When the projects end, however, there is no sustainability to maintain collaborations, a situation that severely reduces their overall impact. To optimize the outcome of successful projects with tangible impact, and to provide continuity over time, the Commission could consider the possibility of offering to exceptional projects, the opportunity to apply at the following FP.

We also endorse the proposal put forward by the Interim Evaluation Report of FP7 calling for a balance between top-down and bottom-up approaches. The latter is crucial because (i) the procedure will appeal to teams of pro-active researchers and clinicians already collaborating and sharing resources, and (ii) scientists will be more alert to the latest developments, for which reason it will be easier to react quickly to new advancements within a given priority area.

Lastly, there is a need for the European Commission and the Member States to better harmonize their research agendas and policies in order to enhance coherence and provide continuity.

- European Research Council (ERC): The ERC is the most prestigious funding instrument within the FPs. It is demand-driven, and funds research solely based on scientific excellence. To date, its support has contributed significantly to a better understanding of the molecular mechanisms underlying cancer as well as other diseases and consequently, it is in a perfect position to fund translational programs as basic research and innovation are interlinked.

In the steps leading to the making of Horizon 2020, the European Alliance for Biomedical Research (BioMed Alliance) proposed the establishment of a "European Council for Health Research" (EuCHR) – shaped along the principles driving the ERC – to boost innovation in health research[204]. The European Medical Research Councils (EMRC) endorsed the scheme, and recommended to the European Parliament and the EC the setting-up of a 'European Clinical Research Fund' "working with a bottom-up approach."[205] The European Federation of Pharmaceutical Industries and Associations (EFPIA) also supported the BioMed Alliance proposal.[206]

Following the above developments, the ERC and other decision-making bodies could contemplate, in due course, the possibility of funding translational research at both pre-clinical and clinical level. The program could support small groups of independent early-career researchers and clinicians as well as more senior multidisciplinary groups of moderate size. Engaging early-career investigators in translational research is one of the cornerstones for developing and strengthening personalised cancer medicine in the years to come. Implementing the task would require raising the budget of the Agency to avoid affecting funding for basic research, which in fact, should increase – in particular to support young independent investigators – as research is one of the few tools that society has to deal with major societal challenges.

We would like to stress that the ERC has recently started the Proof of Concept Grants aimed at "bridging the gap between research and early stages of marketable innovation", an initiative that has been well received and that should be expanded as it is oversubscribed.

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[204]) *http://www.biomedeurope.org/images/pdf/developments/EuCHR_SSB_final.pdf*

[205]) *http://www.esf.org/media-centre/ext-single-news/article/european-medical-research-councils-call-on-a-new-strategy-for-health-research-in-europe-860.htm*

[206]) *http://efpia.eu/mediaroom/75/67/EFPIA-fully-behind-the-idea-of-a-European-Council-for-Health-Research*

Table A.1. Barriers limiting the translation of fundamental discoveries to clinical practice

- *The complexity and heterogeneity of cancer, which comprises many different diseases with a large number of subgroups within each of the tumour types.*
- *Inadequate research coordination at regional, national and EU level.*
- *Insufficient collaboration between DG SANTE and DG Research, Science and Innovation (including national research and health ministries).*
- *Lack of adequate funding to sustain long-term programs. Most current funding mechanisms are short-term and discourage innovation.*
- *Lack of research environments where basic/preclinical and clinical research are integrated, i.e., the CCCs.*
- *Educational, training and mentoring, and workforce (interdisciplinarity) issues.*
- *Lack of models to reward young researches and team efforts.*
- *Lack of harmonized protocols (technology, clinical trials design, data recording).*
- *Suboptimal access to and sharing of biological and clinical data, a barrier to OS.*
- *Poor translatability of preclinical models.*
- *Fragmented supportive infrastructures for high-end technology platforms.*
- *Integration between preclinical and clinical research is suboptimal.*
- *Shortfalls in the clinical trials system (time to activation, patient accrual, etc.).*
- *Complexity of the regulatory environment, legal and ethical issues.*
- *Insufficient late translational research.*
- *Suboptimal collaboration with industry.*
- *Lack of venture capital.*
- *No clear strategy for science-driven innovation.*

Coordination of research programs

- ERA-NETS. As a result of the Eurocan+Plus project recommendations, TRANSCAN was established in 2011 in FP7 to align national research programs within translational cancer research. In Horizon 2020, TRANSCAN-2 (ERA-NET Plus) was funded and currently involves 28 partners from 19 European and Associated countries[207]. Even though the program has been quite successful, it would be necessary to get sustainability to achieve the long-term objectives of "streamlining EU-wide cancer screening, early diagnosis, prognosis, treatment and care". To achieve this goal, Member States should make additional efforts to increase the number of participating funding organisations, and their contributions. Increased funding from the EC will also be needed.

Public-private partnerships

- Innovative Medicines Initiative. IMI is a public-private partnership between the EC and the European pharma industry, which aims at speeding-up the discovery and development of more efficient medicines. In the cancer area, however, the program would benefit significantly by strengthening the interactions between the cancer community – in particular, Cancer Core Europe and other major European consortia – and EFPIA as this will significantly stimulate Open Innovation. Moreover, it would be important to support a two-way traffic between industry and academia.

B. Sustainability of Cancer Core Europe. The success of Cancer Core Europe will very much depend on achieving sustainability. Both Article 185 TFEU and Joint Programming Initiatives (JPIs) support coordination and structuring of national research programs to tackle complex challenges, but are complicated, lengthy to implement, and do not contemplate bottom-up initiatives. Clearly, there is at present an urgent need to modify old funding mechanisms to accommodate bottom-up schemes.

C. Training and mobility of researchers and clinicians. Training in translational cancer research is an unmet need in Europe today, and fostering the mobility of basic research scientists and clinicians across Europe for short as well as extended periods is crucial to secure training across disciplines and technologies as well as for building strong ties for future collaborations. With the advent of Cancer Core Europe and other big platforms, there is an urgent need to ensure that all countries in Europe – in particular, EU-13 countries – benefit from this development. To facilitate training and mobility the following actions could be considered:

- Actively promote the organization of courses, workshops, and Summer Schools in translational cancer research among basic and clinical organizations (EACR, OECI, EMBO, FEBS, ESMO and others), and CCCs.

- Educate the new generation of leaders in cancer research centres. The TRYTRACK program started by Cancer Core Europe is a good example.

- Increase the number of short-term fellowships (Marie Skłodowska-Curie actions) to fund research visits (young and established basic science researchers and clinicians). For EU-13 countries, in particular, this will be essential to acquire competencies and access to new technologies.

- Increase the number of long-term fellowships to fund post-doctoral work (Marie Skłodowska-Curie actions, IF fellowships).

D. Research Infrastructures. Translational cancer research in the era of personalized medicine in an OS culture, requires complex RIs such as clinical cancer registries with treatment data from clinical trials, as well as clinical registries for clinical validation; biorepositories with tumour and normal tissues from patients in clinical trials and validation programmes; early clinical trial structures; molecular pathology platforms; Omics platforms, including proteomics and epigenomics; immunotherapy platforms; molecular imaging structures as well as ICT infrastructures. Their implementation will require the financial commitment from the Member States as well as a better link between national priorities and the ESFRI roadmap. Member States should maximize their efforts. Moreover, depending on the

[207]) *http://www.transcanfp7.eu/pages/welcome-to-transcan-2.html*

size of their country, Member States should establish one or more CCCs in order to optimize translational research, which requires integration of research with the healthcare system.

7. CONCLUSIONS

This case study has briefly described the efforts that the cancer community and policy makers have made since the creation of ECRA by Commissioner Phillip Busquin in 2002, to structure translational cancer research. These actions led to the establishment of Cancer Core Europe, a virtual consortium of six leading European cancer centres having the critical mass of expertise, resources, patients, shared-data, and infrastructures needed to generate stimulating and innovative research environments. Even though the journey has been lengthy and full of uncertainties, Cancer Core Europe has provided a stimulating example of how to build research ecosystems where all the strategic priorities established by Commissioner Carlos Moedas (3 O's) could develop and progress in accord to tackle a major societal challenge. It should be stressed, however, that there is no 'one-size-fits-all' solution to implementing the three priorities in all scientific disciplines, as there are distinct characteristics and restrictions within the different areas of science.

Of the numerous barriers slowing down the translational process across the cancer research continuum (Table A.1), this analysis focused primarily on funding instruments, as these are essential for sustaining translational research and for boosting academic-driven innovations. Translational research is at the heart of Europe's 2020 strategy and the innovation Union, which promises to strengthen the European knowledge base to generate more jobs, improve lives, and create a better society.[208] Clearly, there is also a need to address the other barriers hindering the translation process (Table A.1), but this will require a concerted effort from all the relevant stakeholders. The scientific community is prepared to provide evidence-based advice to underpin policies that allow solutions and inform society of the benefits of research.

Even though the case study centres on oncology, the principles and recommendations apply to all chronic diseases.

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[208]) *https://ec.europa.eu/research/innovation-union/pdf/innovation-union-communication-brochure_en.pdf*

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APPENDIX 3 CASE STUDY:

Climate-KIC: a knowledge innovation community that links 'Open Science' through to 'Open Innovation' and 'Open to the World' – enabling Europe to take the global lead[209]

Mary Ritter

"I am convinced that excellent science is the foundation of future prosperity, and that openness is the key to excellence."

Commissioner Moedas, June 2015[210]

1. INTRODUCTION

Knowledge Innovation Communities (KICs) provide a unique model for open innovation. Moreover, by bringing together partners from across academia, business and government they can build on the research output emerging from Open Science, taking this through an Open Innovation pathway to commercialisation and the market, while also providing a European platform of excellence for international collaboration, replication and global impact – Open to the World. KICs therefore have the potential to play a pivotal role in Europe's innovation success. For this case study, Climate-KIC has been selected as an exemplar of the KIC model to illustrate how this enables the excellence of the output of Open Science to achieve societal and economic impact on the European and global stage.

Established in 2010, Climate-KIC's vision is to enable Europe to lead the global transformation towards sustainability; while its mission is to bring together, inspire and empower a dynamic community to build a zero carbon economy. Climate-KIC accelerates the innovation required for a climate resilient low-carbon future, and ensures that Europe benefits from new technologies, company growth and jobs.

Climate-KIC was one of the first 3 Knowledge Innovation Communities established in 2010 by the European Commission under the aegis of the European Institute of Innovation and Technology (EIT), together with InnoEnergy and EIT Digital. Two further KICs were launched in 2015 (EIT Health, EIT Raw Materials) and two more will soon be selected to start in 2017 (EIT Food, EIT Manufacturing). The EIT and its family of KICs was the brainchild of former European Commission President José Manuel Barroso – established with a three-fold remit: to innovate to address societal challenges, while at the same time boosting the European economy and creating an entrepreneurial culture to combat the risk-averse nature of European society.

The KICs have been a big, and successful, experiment in innovation – bringing together a community of partners across the triple helix of business, academia and government to work across all sides of the knowledge triangle of research, innovation and education – an experiment that is now proving its success. For example, Climate-KIC has delivered €1.8 billion in climate action, showing a leverage multiplier of ~5:1 against its EIT funding received since 2010. Innovation opportunities have been exploited through >130 cross-sector, cross-border partner consortia. In 2016, 250 business ideas were incubated and helped to create >140 companies, while in the 2012-2015 period 170 start-ups graduating from stage 3 of the Climate-KIC Accelerator programme have collectively raised more than €189 million in external investment, with an average KIC:external leverage ratio of ~1:16 (data from 2 KIC centres); and the very high "median" performance (~€2m per start-up) of follow-on funding achieved by one KIC centre is a world-leading result reflecting consistency of performance across the investment portfolio. Education programmes have created almost 2,000 alumni – our change agents for entrepreneurial climate action across Europe and the world.

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209) This case study is written by Mary Ritter, Chair of RISE Open Science group

210) Commissioner Moedas (2015), A new start for Europe: Opening up to an ERA of Innovation, Brussels, 22 June 2015

2. WHAT IS C LIMATE-KIC?

Climate-KIC has established a thriving, long-term knowledge innovation community that crosses discipline, sector and national boundaries – a trusted ecosystem for Open Innovation.

Working across sectors and across national boundaries

Launched in January 2010 with fewer than 20 founding partners, our community has now grown to encompass more than 200 organisations. These come from a wide range of sectors including world-class universities (we have 8 rated in the world top 100[211],[212]), world-leading large corporates, small and medium enterprises (SMEs), aspirational city and regional governments and NGOs.

Our partners and activities cross many national borders, bringing together innovators from 24 countries across Europe: Belgium, Bulgaria, Cyprus, Denmark, Estonia, Finland, France, Germany, Hungary, Italy, Ireland, Latvia, Malta, Norway, Poland, Portugal, Romania, Serbia, Slovenia, Spain, Sweden, Switzerland, The Netherlands, and the UK. Thus we bring together partners across the north, south, east and west – fostering innovation across the emerging and developed economies of Europe.

Connecting with partners and citizens across the world through both a physical and a digital innovation ecosystem

We bring our partners together in 6 main geographical clusters, providing physical co-location centres for face-to-face meetings and collaboration. Whilst this physical interaction is important, much of our interaction and work – across the continent and beyond – takes place in a digital environment. This virtual communication boosts our connectedness, increases our innovative creativeness and helps to curb our carbon footprint. For example, we have created an e-learning platform for our education programmes, we use webinars for strategic discussion, and many executive, thematic and other meetings take place by video-conferencing. Open innovation platforms linked to our major programmes are under development.

[211]) *http://www.shanghairanking.com/ARWU2015.html*

[212]) *https://www.timeshighereducation.com/world-university-rankings/2016/world-ranking#!/page/0/length/25/sort_by/rank_label/sort_order/asc/cols/rank_only*

Through social media we can reach citizens across the world. We have more than 42 thousand fans on Facebook with a reach of 18.8 million in 2015 and over 15 thousand followers on Twitter with a reach of 8.3 million in 2015. There were 1.37 million website views in 2015 for http://www.climate-kic.org/. We also use the Daily Planet for content marketing. This started in December 2015 at COP21, as a daily newsletter during the conference and then, due to its success, became a news website and weekly newsletter in February 2016, with 36 thousand views and 6.5 thousand email sign-ups so far – from across Europe and the world[213].

Both physical and virtual interaction plays a key role in innovation, supporting planned innovative activities, but also, very importantly, enabling serendipitous personal interaction and knowledge exchange that is so crucial for disruptive innovation.

A trusted environment for open innovation

Our partners join to become part of the long-term Climate-KIC community, and not just for a single activity. This enables the development of understanding and trust between partners across the academic-business-government boundaries – creating, as one of our large corporates said, "a trusted environment" in which for the first time they feel comfortable working in open innovation. This trusted innovation community is a key feature of the KIC model – our USP.

Run as a business

Climate-KIC is a not-for-profit company (a Dutch Holding BV) such that income will be re-invested in KIC activities. The Assembly of Core partners is the sole shareholder in the company, with responsibility for guiding the strategy and annual budget allocations. An Executive Board comprising CEO, CFO, COO together with two Directors representing the thematic and geographic axes of the KIC matrix, are responsible for management of the KIC. Although currently dependent upon a grant from the EIT, this funding is planned to progressively decrease, replaced by diverse sources of external finance, revenue and investment – with the longer-term trajectory leading to financial independence and sustainability. Thus, money

[213]) *http://dailyplanet.climate-kic.org/*

put into activities by Climate-KIC is considered as an investment, such that all KIC-funded activities must have a longer-term sustainability plan – leveraging appropriate sources of external funding.

Success is measured by output, outcome and subsequent impact on climate change and the economy of Europe – mitigating the causes of climate change, adapting to the effects of climate change, creating jobs and leveraging finance.

3. WHAT DOES CLIMATE-KIC DO?

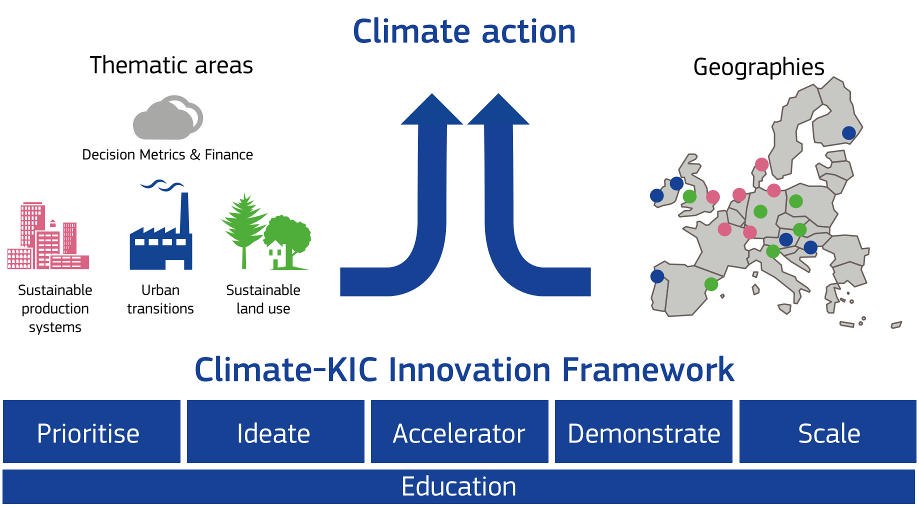
Climate-KIC runs an integrated innovation demand-led and challenge-driven pipeline

Climate-KIC runs an integrated innovation pipeline focussing its activities in four thematic areas: Sustainable land use, Sustainable production systems, Urban transitions and Decision metrics and finance (see figure below). This pipeline takes the innovation process from prioritisation, ideation, acceleration and demonstration through to commercialisation and scaling up – via a range of activities including climate launchpads, climathons (climate hackathons), small market scoping projects, larger demonstration and scaling projects, and acceleration support for start-ups. Key to much of this innovation pipeline is the excellence of partners' up-stream scientific research, with the KIC taking this through to supporting the development of products and services (mainly from ~TRL4 onwards). Climate-KIC thus creates the conduit from Open Science to Open Innovation, taking world-class science developed within its partner community, or from the external ecosystem, through to innovation and the market.

One of the best examples of Open Science is in the area of climate science where the work of 1000's of scientists has been shared and reviewed, contributing to the five reports of the Intergovernmental Panel on Climate Change (IPCC), published between 1990 and 2014. Excellence in scientific data and modelling has been key to all these, leading to successive IPCC reports showing with greater and greater certainty the anthropogenic impact on climate change. This played a crucial role in the success of COP21 – with the unprecedented international agreement that emerged, addressing the most serious challenge facing mankind today.

However, to move from open science, political and legal decision-making to addressing climate change mitigation and adaptation in practice requires different skill sets to enable this to be taken forward to deliver implementation in an economically viable/beneficial manner. The example in Box 1 (below), shows that this is where Climate-KIC, acting as an independent body, has enabled the transition from Open Science to Open Innovation – through its cross sectorial partner community and innovation framework of support.

Figure A.4: Delivering impact through demand-led innovation



Climate-KIC runs a world leading cleantech Accelerator

Climate-KIC runs the most effective cleantech Accelerator for start-ups in Europe, with an excellent track record in bringing more innovation to market and faster. The programme is developed and coordinated at European level, but delivered locally within our Climate-KIC centres across the continent. Start-ups are taken through 3 stages: business model creation, customer discovery, becoming investor-ready. Climate-KIC makes a small investment in each start-up (€15-50K per stage), but what has the greatest impact is the tailored support that they receive throughout their stay in the Accelerator. Of the 533 start-ups that have entered the Accelerator since its inception in 2012, 170 of these have completed stage 3 of the programme and by the end of 2015 had collectively raised €189 million of external funding – an impressive average leverage ratio for KIC grant:external investment of ~1:16 (data from 2 KIC centres) – with leading start-ups winning top honours at Silicon Valley Cleantech Awards and other international accolades for their business ideas and growth. The very high "median" performance (~€2m per start-up) of follow-on funding achieved by one Climate-KIC centre, showing consistency across the investment portfolio, is a world-leading result. An estimated ~2,000 jobs had been created.

Many of these start-ups have been developed by students and researchers within Climate-KIC's universities and research institutes across Europe, and also within universities outside the KIC within the broader European ecosystem – again illustrating the strength of the KIC model in linking Open Science with Open Innovation.

Climate-KIC's activities integrate the three sides of the knowledge triangle: research, education and innovation

A special feature of the KIC model is the integration of the three sides of the Knowledge Triangle: education, research and innovation which are interwoven throughout the innovation pipeline (summarised in the figure below). The unusual involvement of education in innovation has three key impacts. Firstly, education supports the innovation framework itself providing, for example, ideation activities such as the Journey and Greenhouse (see text section below for further detail). Secondly, education trains and develops entrepreneurial human capital for the innovation pipeline, and in addition contributes more broadly to a societal culture change (away from being risk-averse), through its postgraduate, professional and executive programmes. The Climate-KIC Alumni Association now has ~2000 members – creating a European and global diaspora of climate entrepreneurs and change agents. Thirdly, in an innovative educational feedback loop, the learnings from Climate-KIC's innovation programme and experiments in innovation are incorporated into the new learning materials for novel experiential education activities. Through this approach, young scientists receive an experiential training in entrepreneurship and open innovation, building on the academic foundation of their chosen scientific area – furnishing the next generation of scientists with the skills to understand the crucial progression from open science to open innovation. Professional and Executive programmes, and online activities are also a key part of the education portfolio but will not be discussed further here.

Climate-KIC Oasis[214] project – from science to innovation. Open access modelling driving adaptation to enable climate resilience

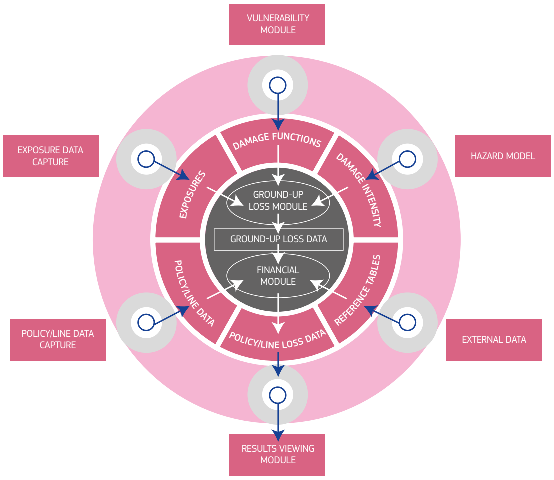
Risk management and adaptation to climate change, in particular in the context of increasingly frequent extreme weather events, is crucial if the costs of catastrophe loss – both human and financial – are to be kept under control. However, a lack of accessible, consistent high quality data and an understanding of catastrophe and climate risk have inhibited governments and other organisations from making the necessary decisions, investments and implementation to deliver adaptation. The goal of Oasis is therefore to provide the models, tools and services to enable informed catastrophe and climate risk assessment, planning and appropriate investment decisions on climate adaptation. These models can be used for anyone wishing to understand the consequences of extreme climate impacts on assets (for example the built environment or agriculture).

OASIS has developed an open-source loss modelling 'kernal' (the Oasis Loss Modelling Framework, (Oasis LMF[215]) with a range of plug and play catastrophe and climate models whose data address a wide range of natural disasters affecting different areas of the world (see figure below). Oasis LMF calculates the potential impacts and losses, enabling organisations to plan for and to insure for such events – building adaptation capacity and improving the viability and functioning of the insurance sector. The core competence and advantage of Oasis lies in the underlying robustness of the data, and the models that must first meet certain standards before being used by Oasis LMF. Many of these models are the output from the excellent science of Climate-KIC partners such as the Technical University of Delft (e.g. flash flood), the Potsdam Institute for Climate Impact (e.g. central European flood) and Imperial College London (e.g. infrastructure risk, tropical rain and crop risk, insurance linked securities), Deltares (Dutch flood), ARIA (Oasis fire, Oasis rain – South America).

214) *http://climatefinancelab.org/idea/climate-risk-assessment/*

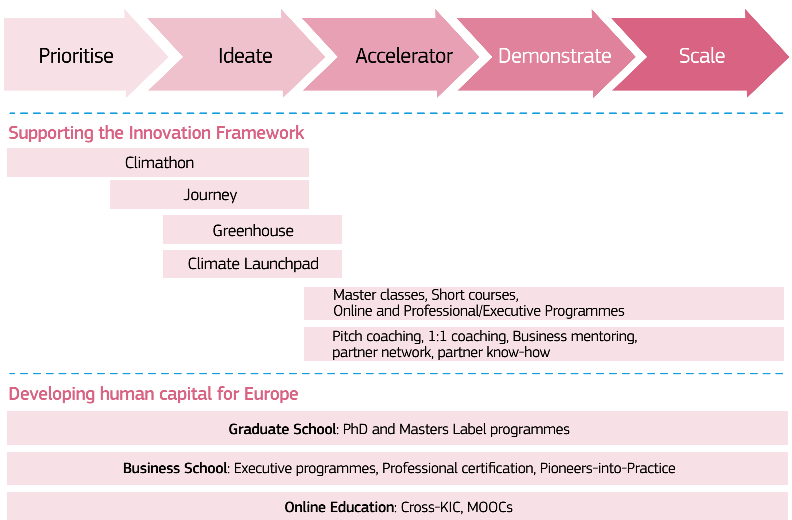
215) *http://www.oasislmf.org/*

Figure A.5: Challenge driven innovation



Oasis started in 2011 as a cross-university consortium developing risk models. Now in 2016, the project has 12 core partners, and a broader programme membership body of stakeholders comprising 44 global insurers and reinsurers, together with 60 associate members from the commercial and academic model development community. The open marketplace for data and tools has huge potential for governments, corporations, aid organisations and, eventually, individuals – potentially saving lives, property and infrastructure. This Climate-KIC project Oasis Loss Modelling Framework was been named Innovation of the Year at the London Market Awards 2014.

Figure A.6: A supported integrated Framework



Climate-KIC Accelerator – from science to start-up success

In the period 2012-2015, 170 start-ups graduated from stage 3 of Climate-KIC's Accelerator programme, collectively raising €189 million external funding (e.g. Venture Capital, Crowdfunding). This success is continuing in 2016, with several hundred start-ups developing progressively through stages 1, 2 and 3 of acceleration. Many of these have emerged from scientific research undertaken within Climate-KIC's universities and research institutes across Europe – showing the potential for translation from open science to open innovation. Below are just three of the examples of Climate-KIC's many successes – and successes for our battle against climate change – from the Climate-KIC accelerator programme in our European centres.

Econic Technologies[216] "Turning carbon dioxide (CO_2) waste into a benefit for business and the planet". Econic Technologies develop novel catalysts for polymerisation. The company partners with plastics manufacturers to enable them to use CO_2 as a raw material in the production of materials such as plastics, elastic films, coatings and foams for potential use in cars, mattresses, running shoes etc. Not only does this provide manufacturers with an alternative to using oil in their production processes, it also enables them to use one of their own waste materials – CO_2 – benefitting both the company and the environment! Econic's underlying technology emerged from scientific research in the Department of Chemistry at Imperial College London[217], a partner in Climate-KIC. The start-up was founded in 2011, and was supported through the staged programme of the Climate-KIC Accelerator in the KIC's UK centre. Econic Technologies has received many awards including joint winner of the 2013 Climate-KIC Venture Competition, the Royal Society of Chemistry's 2014 emerging technologies award in the category 'Environment, materials and process chemistry' and the Shell UK Chairman's Special Award at the prestigious Shell Springboards 2015 awards. Since inception, Econic has received almost £13 million external investment, with £5 million from their latest round in 2016.

Eternal Sun[217] "Competing with the sun"

Eternal Sun was founded in 2011 by researchers at Climate-KIC partner Delft University of Technology[219]. Scientists who were researching solar panels realised that they needed an accurate solar panel testing kit – something that did not exist. They therefore set up the Eternal Sun company to provide accurate sunlight simulation equipment, mimicking real sunlight, to enable customers to test their solar panels under a wide range of conditions – and for a fraction of the multi-million Euro costs of the competing large scale testing facilities previously available. Eternal Sun was founded in 2011, supported by the start-up incubator Yes!Delft[220], another Climate-KIC partner,

[216]) *http://www.econic-technologies.com/*

[217]) *https://www.imperial.ac.uk/*

[218]) *http://www.eternalsun.com/*

[219]) *http://www.tudelft.nl/en/*

[220]) *http://www.yesdelft.com/*

and by the Climate-KIC acceleration programme in the KIC's Dutch centre, gaining access to expert coaching, international master classes, a US start-up tour and Climate-KIC's Venture competition – which they won! Eternal Sun has attracted €2 million external investment, has 20 full-time employees and customers on every continent, and recently acquired Spire Solar, the solar testing division of their US competitor Spire Corp – significantly increasing their impact.

GreenTEG[221] "Sensing the environment"

GreenTEG's technology focuses on sensing applications for environmental monitoring and internet-of-things. Their products include laser detectors, heat flux sensors and customised sensor solutions, with customers from scientific, medtech and building sectors. For example, greenTEG sensors can optimise buildings so that they lose less energy – making an important contribution to reducing the carbon footprint. Technologies are based on a novel manufacturing process developed at Climate-KIC partner ETH Zurich, within the Department of Micro- and Nano-systems[222]. GreenTEG was spun out in 2009 and was supported by Climate-KIC accelerator programme through stages 1, 2 and 3 in the KIC's Swiss centre, and won the Swiss and European Venture competition in 2012. It has subsequently won several other awards including Venture Kick stage 1 and 2, De Vigier Award, Swissexellence product award and Ventureleaders China. The company now has a wide range of products and customers across the world.

The Journey: developing Europe's science-based entrepreneurs and climate change agents

The Journey is a key programme of the Climate-KIC education theme, focusing on facilitating systemic thinking and climate change innovation via a learning-by-doing approach. In the 5-week summer school, an international community of like-minded postgraduates and postdoctoral researchers are taken on a journey of professional and personal development, whilst developing viable and innovative business ideas to address the challenges of climate change mitigation and adaptation.

The programme starts with a 3-week on-line pre-Journey ('Ideation for Climate Business') culminating in an ideation workshop to prepare students for the Journey itself. Following this, the students' 5-week 'Journey' takes them to three of Climate-KIC's centres across Europe. They first focus on climate change science, challenges and policies – ideating on solutions with the support of professional business coaches. Next, they build on this, gaining the tools they need to build up their business ideas, with input on market research, project management, branding, finance and pitching. Finally, they focus on completing and pitching to a venture panel. For those teams that successfully generate viable business ideas, Climate-KIC provides pre-acceleration support (Greenhouse), compatible with their continuing university studies, to get them ready for entering the Accelerator.

For many students, the Journey is a life-changing experience. These will be the next generation of entrepreneurs, trained in the environment of Open Science in their universities, while also experiencing the practice of Open Innovation.

[221]) *http://www.greenteg.com/*

[222]) *http://www.micro.mavt.ethz.ch/*

The Journey – from Climate-KIC student science to Climate-KIC innovation

Since the first Journey was run in 2010, over 250 business ideas have been developed by students participating in Climate-KIC's 5-week Journey, and from these more than 200 students are working in start-ups and >20 start-ups have been successfully launched. The ideas for these start-ups build on the students' academic and research experience within their 'home' Climate-KIC partner university, enabled by their entrepreneurial experience and business support provided by the Journey programme. Our exceptional young entrepreneurs have been recognized by the prestigious Forbes 30 under 30[223], where, in 2015, 3 of the 30 selected young social entrepreneurs were from the Climate-KIC Journey (and a further 2 were from members of Climate-KIC and Innoenergy respectively). Below are three examples of Climate-KIC's many student start-ups.

Students A and B – worked together to create Coolar, a start-up developing a sustainable refridgerator using no electricity, while they were completing their PhD studies at the Technical University of Berlin[224]. They attended the Climate-KIC Journey, then Greenhouse, and are now in Stage 3 of the Climate-KIC Accelerator. Coolar's refrigerators run with hot water (from solar heat) not electricity, so they are almost carbon neutral. They are ideal for use in remote areas in hot climates with no access to an electricity grid – providing much needed off-grid, reliable and eco-friendly equipment for storing essential vaccines and food. Coolar was nominated for best new product for Off-Grid Expert Awards 2015, and was one of six start-ups nominated for the StartGreen Award competition 2015.

Student C – is finalising her PhD in chemical engineering at Imperial College London[225]. She and a fellow Climate-KIC Journey team member established Oorja[226]– a start-up that aims to build and deploy decentralized hybrid solar and waste mini power plants that will provide affordable and reliable electricity for commercial power and household lighting to more than 400 million people in India (Oorja's mission is to impact over 1 million people by 2025). The hybrid power plants will sustainably transform agricultural crop waste through a gasification process to generate electricity and biochar that can be used in sustainable agriculture. Oorja will be run through a micro-franchise model enabling it to develop a highly extended reach. The Student and her Oorja partner were awarded 'echoing green fellowships' in 2015[227]. Having attended the Climate-KIC Journey, Student C also attended the Climate-KIC Greenhouse, and is currently in this pre-acceleration phase. She is applying for Oorja to enter the Climate-KIC Accelerator. This student is one of the Forbes 30-under-30 2016.

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[223]) *http://www.forbes.com/30-under-30-2016/social-entrepreneurs/#3576b3076004*

[224]) *http://www.tu-berlin.de/menue/home/parameter/en/?no_cache=1; http://coolar.co/*

[225]) *https://www.imperial.ac.uk/*

[226]) *http://www.oorjasolutions.org/*

[227]) *http://www.echoinggreen.org/fellowship*

Student D – completed his PhD at Imperial College London on organic photovoltaics. In collaboration with one of Climate-KIC's most exciting new start-ups, MeshPower Ltd[228] (the majority of whose employees also studied at Imperial), and the Danish Technical University[229], he ran field tests on lighting from solar power for homes, working within Rwanda's rural communities[230], using his expertise and scientific knowledge to help develop this innovative start-up. MeshPower has developed solar powered nanogrids that can provide electricity for around 100 homes and business in a village. Villagers share the electricity produced, but each has their own account. The company has been expanding its services rapidly since it started in 2014 and now offers affordable, reliable and clean energy to over 45 different Rwandan villages in the Bugesera district, south of Kigali. It has just connected its 1000th customer – a young farmer in Nganwa Village, Bugesera[231]- "I was tired of living in the dark" she said.

The Journey is a life-changing experience for many students. Below are some comments from the 2016 students:

- *I absolutely loved being a participant on the Journey! It challenged me to get out of my comfort zone, encouraged me to go after my dreams and motivated me to put in the work that is need to succeed!*
- *Overall I feel empowered to pursue an entrepreneurial path in the field of climate change*
- *This journey was life-changing. Thank you Climate KIC for this wonderful experience, it will indeed have a great impact on my future career and bring great returns hopefully to the world.*
- *I don't know yet where the Journey will lead me to but it really has been a terrific experience and opened doors in reality as well as my head by seeing the opportunities. – Please do keep setting it up – I promise I'll make the EU's investment worth-while! – Whether in 2, 12 or 20 years, a little light for changing the world through action has been set on fire. Let's make it happen together!*

[228]) *https://www.meshpower.co.uk/*

[229]) *http://www.dtu.dk/english*

[230]) *http://www.climate-kic.org/blog/fortnight-rwanda/*

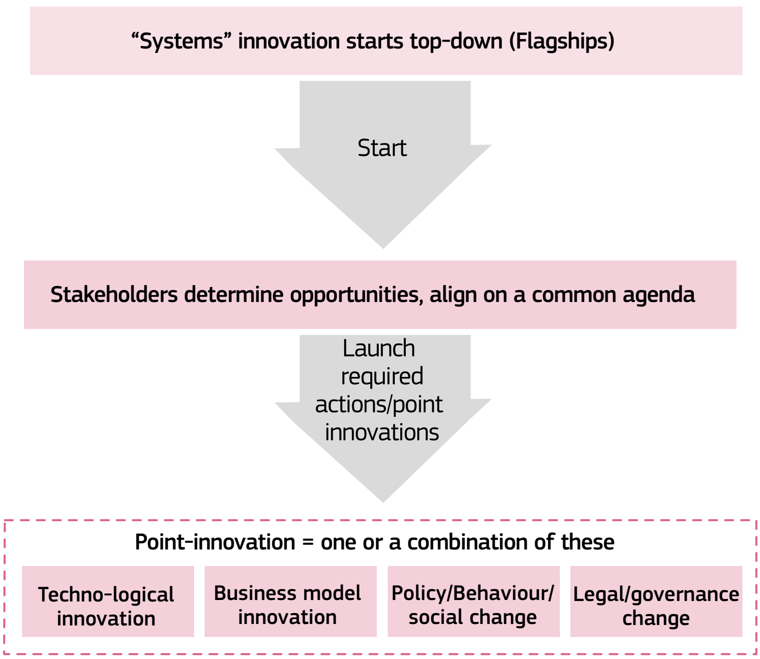
[231]) *http://www.climate-kic.org/news/meshpower-solar-lights-rural-rwanda/*

Climate-KIC addresses complex challenges with a systems approach to innovation

Arising from its community structure and culture, Climate-KIC is uniquely placed to address complex societal challenges through a top-down systems innovation approach. Stakeholders come together across sectors to discuss a shared challenge, determine the opportunities and align on a common agenda. They can then build on excellent science to launch appropriate actions to generate and integrate bottom up point innovation – providing a coordinated approach to the development of effective solutions.

Specifically designed to take this systems approach, Climate-KIC has developed a portfolio of 'flagship' programmes – for example: accelerating uptake of climate-smart technology in the building sector; integration and co-ordinated delivery of innovation at city district/precinct level; boosting climate smart agriculture; and supporting sustainable production systems via use of carbon dioxide as a raw material to make chemicals, foams and rubbers (see Box 4 next page).

Figure A.7: Systems innovation, driven by stakeholder community



Climate-KIC Flagship programmes: a systems approach to taking scientific research through to open innovation

Climate-KIC's flagship programmes are developed to address complex societal challenges through a systems approach to open innovation. Climate-KIC partners and stakeholders come together from across business, research, university and government sectors to identify the challenges, determine the opportunities and align on a common agenda to address climate change mitigation and adaptation. A range of activities is then developed, to support the full flagship value chain, from ideation through to market – including launchpads, climathons, innovation projects, accelerator and education programmes – to collectively work on the shared challenge. Climate-KIC currently has a portfolio of 5 flagship programmes. Below is an example of one of these: EnCO$_2$re.

EnCO$_2$re flagship programme[232]

The mission of EnCO$_2$re is to enable CO_2 reuse – using carbon dioxide as a raw material – for example in producing polymers to create rubbers and foams for products such as mattresses – replacing oil-based feedstock with CO_2, and so closing the carbon loop (not only reducing greenhouse gas emissions, but also capturing and using existing emissions). The long-term systemic challenge is to create a more sustainable future where CO_2 is used extensively as feedstock for new or improved products and where consumers and companies actively demand products made from CO_2. CO_2 re-use could thus be a key component of sustainable European growth.

EnCO$_2$re is led by the company Covestro, working with 11 other Climate-KIC companies and university/research partners from seven countries across Europe. Collectively, these Climate-KIC partners contribute to shaping and delivering the flagship programme. The flagship currently looks to develop: an innovation programme that supports technology and product development; new technologies offering novel ways to use CO_2; increase awareness for CO_2 re-use; and ensures sustainability and social acceptance of materials and products by integrated socio-ecological research. It is a multi-annual programme with a long-term perspective and has the ambition to create a full commercially viable value chain from CO_2 emitter to end-user.

The flagship is still at an early stage, but already the transfer of knowledge from scientific research to innovation has started to have impact. Formal knowledge adoptions and knowledge transfers from university research to business opportunity have enabled the flagship team to: pinpoint useful sources of CO_2, and to identify who is engaged in CO_2 re-use – across Europe and worldwide (see below). These data are being used to bring stakeholders together to create new connections and develop the shared agenda. Examples of such knowledge transfer include:

[232]) *http://enco2re.climate-kic.org/*

- *A publically available CO_2 source visualization tool*[233] *has been developed by the Technical University of Delft, based on data analysis by Chalmers University of Technology*[234]*. This has made it possible for companies such as Covestro to see graphically where sources of CO_2 exist, and to characterise them by size and purity. In addition, a set of complementary materials*[235] *demonstrates locations where CO_2-based materials can be made.*
- *Similarly, cluster analysis using an indirect method has enabled Chalmers to calculate local-level production data where no data were available. Chalmers is now working on a higher resolution study.*
- *Finally, Climate-KIC partner TU Berlin*[236] *has contributed to the projects section of the publically available CO_2 utilisation database*[237] *– the world's largest known catalogue of CO_2 re-use projects and research sites, with a global reach.*

4. CLIMATE-KIC ON THE WORLD STAGE – OPEN TO THE WORLD

Climate change is a global problem; and as a world-leading organisation, Climate-KIC must deliver climate impact at global scale. The KIC model is well suited to promulgate this. At minimum, it provides an excellent platform for collaboration. At maximum it is a European model that can set the 'gold standard' for replication in other parts of the world.

As a 'gold standard' we are therefore delighted to be working with a cross-sector group of organisations in Australia, including business, state governments and universities, that, impressed by the European model, has launched an Australian version of Climate-KIC this year – with a mission "to act as a catalyst for demand-led, systems-scale solutions through connecting key players across the whole innovation pathway and ensuring synergies are realised". While based in Australia, the organisation will develop broader links into the Asia-Pacific region, and is likely to expand further into the region in the future.

This creates excellent opportunities for collaboration and exchange between Europe and Australia and eventually more broadly in the Asia-Pacific region – enhancing innovation, business and economic opportunities. Current work is therefore focussed on establishing a strong reciprocal collaboration between the European and Australian entities. Such global engagement, using the KIC model as the interactive platform, strongly underpins the link between Open Science and Open Innovation – taking it through to Open to the World.

233) http://enipedia.tudelft.nl/EPRTR/CO2_source_visualization.html

234) http://www.chalmers.se/en/Pages/default.aspx

235) http://enco2re.climate-kic.org/wp-content/uploads/2015/11/CO2-usage-potential.jpg

236) http://www.entrepreneurship.tu-berlin.de/ccu/

237) http://database.scotproject.org/projects

Climate-KIC on the world stage – Open to the World

Climate-KIC Australia: an independent KIC platform providing global reach and opportunities for European/Asia-Pacific collaboration – Building on the best in Europe, creating a distinctive solution for Australia

In order to deliver on the twin objectives set by EIT – to deal with climate change and to boost the European economy – Climate-KIC must act on the global stage. As Europe's world-leading organisation that delivers climate action, it is ready to take on this global challenge for Europe. The KIC model is well suited to deliver climate impact at global scale – providing a European model that can set the 'gold standard' for replication in other parts of the world.

Following extensive consultation within Australia during 2015/2016, a group of Australian organisations across business, academia and state government has now established 'Climate-KIC Australia', a climate knowledge innovation initiative based on the model successfully pioneered in Europe. The initiative will catalyse not only the national response to climate change but will also open up a wide range of opportunities for European-Australian collaboration – for research, education, start-ups, business and government. A business case was developed demonstrating a compelling value proposition for Climate-KIC Australia as a national private/public partnership that links investors, industry, SMEs, government, research and higher education organisations with start-ups and entrepreneurs through a demand-led pipeline. Climate KIC Australia is a not for profit company limited by guarantee, with a Board on which the European EIT Climate-KIC is represented; it will begin full activities in 2017.

Climate-KIC Australia will focus on three key initial challenges

Net-zero carbon energy – vital if Australia is to meet its greenhouse emissions reduction goals as the energy sector is currently the greatest contributor to Australia's emissions at 53%;

Sustainable resilient cities – reducing the impact of cities will make a substantial contribution to climate mitigation, while preparing cities to adapt to inevitable climate changes will improve resilience; and

Regions in transition – providing a structured approach to assist regions and towns embrace the inevitable economic transition away from carbon-based industries.

A collaboration agreement between the European and Australian entities will provide a firm foundation for collaboration across a wide range of shared challenges and activities, underpinning the link between Open Science and Open Innovation – and taking it through to Open to the World.

To launch this exciting collaborative enterprise, 6 Australian cities participated in the 2016 Climate-KIC Europe global Climathon in October – alongside more than 50 cities worldwide, bringing together the world's community to address climate.

5. IN CONCLUSION

The knowledge innovation community of Climate-KIC, and its five current sister KICs, provides a unique model through which Europe can take the output of excellence from Open Science through to Open Innovation and Open to the World – enabling both societal and economic impact. The KICs therefore provide a highly effective approach to addressing society's major challenges in a way that also bring substantial benefit to Europe's economy. For Climate-KIC, we are doing this in the context of the biggest threat that mankind and our planet are facing – the challenge of climate change.

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